The Structure of Abstracts: Stylistic and Structural Elements in 48 Scientific and Technical Abstracts.

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THE STRUCTURE OF ABSTRACTS: STYLISTIC AND STRUCTURAL ELEMENTS IN 48 SCIENTIFIC AND TECHNICAL ABSTRACTS

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TABLE OF CONTENTS

LIST OF TABLES

ABSTRACT

The purpose of this dissertation is to identify and account for the structural and stylistic features of 48 abstracts written by scientists and engineers at the research and development division of a large company. All of the abstracts were published in industry journals and conference papers during 1990 and 1991. The features identified in the abstracts are compared to the suggestions for structure and style found in fifteen textbooks frequently used in university technical writing courses. Textbook suggestions for structural features include purpose statement, scope, methods, results, conclusions, and recommendations. Textbook suggestions for stylistic features include eliminating unnecessary words, avoiding telegraphic writing, using transitions, and avoiding jargon.

Features found in the 48 abstracts differed markedly from the textbook suggestions. The major findings are: a statement of scope is found in 96% of the abstracts, while suggested by only 12% of the textbooks; agentless passive construction is the most prominent stylistic feature of the abstracts, while textbooks suggest avoiding passives; the two types of abstracts defined by the textbooks, "descriptive" and "informative," do not adequately describe the four summarizing strategies found in the abstracts, "the narrative focus," "the definition of terms," "the statement of facts," and "the statement of results." Reasons for the disjunction between textbook suggestions and the outcome of practicing technical writers are discussed, including tacit knowledge of the reader and writer and theoretical versus applied strategies for writing abstracts.

CHAPTER ONE

INTRODUCTION

A survey done by the Westinghouse Corporation in 1962 (Dodge, 1962) indicates that a report's abstract is read by virtually all readers of that report regardless of which other parts they choose to read. Huckin, as reported in Swales (1990, 15), provides evidence to support this conclusion, having found the same pattern in a study of the reading habits of six senior scientists. In both of these studies, all readers began by reading the title followed by the abstract.

Readers choose to read abstracts for several reasons, not the least of which is that an abstract provides the appropriate context or grounding which helps the reader to understand the rest of the report. Yet in the thirty years since the Westinghouse survey appeared, there has been scant research to describe the structural and stylistic elements which make up effective technical and scientific abstracts (Moran and Journet, 1985, 300). A review of the literature on abstracts shows that even though there is a universally held view of the value of abstracts, the published advice about how to structure an abstract is not only limited, but is somewhat idiosyncratic and even occasionally contradictory. Of the attention that has been given to the individual parts of a report, most has been given to openings, such as titles (Francis, 1974) and introductions (Lipson, 1983), and there are only occasional articles on abstracts (see Sekey, 1973, Orth, 1972, Locker, 1982, and Roundy, 1982 below).

The purpose of this dissertation is to provide some detailed information about the structure of abstracts that are published in industry journals and conference proceedings. To provide this information, I will examine the stylistic features (use of cohesive elements, conjunctions, first person, passive voice, jargon, abbreviations, parallel structure, and telegraphic writing) and structural features (purpose, scope, methods, results, conclusions, and recommendations) of 48 published abstracts written by scientists and engineers at the research and development division of a large corporation. Since little empirical work has been done to determine the makeup of abstracts of technical and scientific reports, this dissertation may be the first of its kind to study the complete abstracts of practicing scientists and engineers. It is the purpose of this dissertation to provide information on four basic issues concerning abstracts:

1. What is the present state of knowledge in the published literature about how to structure an abstract?

2. How are the abstracts in this study structured?

3. What are the significant differences between the advice in published literature and real world practice?

4. Most important, what accounts for these differences?

To answer these questions I will outline the general importance of the abstract in a technical or scientific document, place that importance in current themes of technical writing research, review a representative set of technical writing textbooks and journal guides for statements defining abstracts, and develop a detailed analysis of the structural and stylistic data gathered from the 48 abstracts. I will then discuss what appear to be the reasons for any differences between the textbook and journal guide suggestions about how to structure abstracts and the data from the sample abstracts in this group. In particular, three areas of disjunction will be discussed. First, the traditional textbook distinction between the informative abstract and the descriptive abstract will be outlined to show that such a distinction does not appear to accurately describe the functional categories found among the 48 abstracts examined here. Some alternative descriptive categories will be recommended. Second, passive sentence construction will be discussed since these 48 abstracts show an almost even mix of active and passive sentence constructions in contradiction to the advice of many technical writing texts. Third, the most often recommended structural elements found in the textbooks and journal guides will be contrasted with the most frequently used structural elements found in this group of abstracts. The textbooks suggest that the most important elements in an abstract are the conclusions and recommendations, while the 48 abstracts studied here seldom include conclusions or recommendations. Instead, the most often included structural element is a description of the scope of the project or experiment.

Several important reasons exist for studying abstracts in nonacademic writing. In general, as Faigley says, "job-related writing is worthy of our interest and serious study" (1985, 231). According to Bazerman and Paradis, "we consistently find texts functioning to consolidate professional interests, enroll novices into the professions, and direct human activity with far-ranging social consequences" (1991, 10). In particular, however, five specific reasons for the importance of studying how the abstracts of technical and scientific reports are structured emerge from the literature:

1. the abstract is used by readers to determine which reports most closely fit their needs or interests since the abstract identifies the subject and the important findings of the study being described,

2. the abstract is an effective preview for those readers who will read the entire report, in which case the abstract functions as a "warming up" device for the mental cataloguing that will be done by the reader,

3. the abstract is an aid for indexing, since key words are drawn from abstracts for placing the abstract in either electronic or manual databases,

4. the abstract of technical documents is of value to people attending conferences who are selecting talks they would like to attend or are preparing questions they would like to have answered,

5. and finally, as noted in the Westinghouse study above, the abstract is the most frequently read part of a report receiving 100% of the readership compared to 15% for the body of the report and 50% for the conclusion (Houp and Pearsall, 1988, 35).

Although it is well recognized that abstracts are an important part of a report, the need for this study arises from the lack of information about writing abstracts in non-academic settings. In addition to a lack of clear, published guidelines for structuring abstracts, which will be seen in Chapter Two, evidence from the authors of the 48 abstracts studied here indicates that experienced technical and scientific writers are not aware of using any conscious plan to construct their abstracts. When ten of the authors were asked for their strategies for constructing abstracts, they were unclear as to any specific or orderly method they used for abstracting. Analyzing the abstracts themselves, however, provides insight into what appears to be a strategy used by these writers as indicated by the structural and stylistic elements they chose to include and those they chose to leave out. This dissertation will map that strategy using the data derived from analyzing the 48 selected abstracts.

THE WRITERS

The authors of the reports from which the 48 abstracts for this study were taken are scientists and engineers employed by the research and development division of a large corporation. Many of them hold doctoral degrees in their fields. They are water chemists, nuclear engineers, exotic metals experts, and specialists in heat transfer. They are highly articulate scientists and engineers and are quite capable of describing what goes on when "a" meets "b" under condition "x." When asked about the details of an experiment they are working on, they will enthusiastically offer to demonstrate their work first hand by going to the lab. When asked about their abstracting strategies, however, they provided little insight into how they went about abstracting their reports. Here are some of the responses they gave:

- "I've never really given it a great deal of thought."
- "It's hard to break it down into steps."
- "I never really thought of a strategy, I just do it."

- "Frankly, I don't remember writing the abstract."
- "We just wing it."
- "Styles vary from person to person and methodologies are different for each person."
- "The introduction, slightly revised, is usually sufficient because there is no time to work on a separate abstract."
- "I use the introduction and the conclusion. That's usually enough."
- "I have no real strategy."
- "I don't have a systematic method."

This difficulty in describing well-practiced habits is a common phenomenon among "subject matter" experts in many fields. When software engineers attempted to produce "expert systems" (programs that make human-like decisions based on a large database of branching information), they found great difficulty in extracting information from human experts (Harmon and King, 1985). In diagnosing meningitis, for example, the array of variations the disease displays as well as the number of symptoms for each variation makes accurate diagnosis an art rather than a science. The art of accurately diagnosing the disease resides in a few "experts" who make decisions based on the physical evidence, on theoretical knowledge, and on their previous experience. When software engineers attempted to capture this knowledge in an expert system so that the information could be used in cases where no "experts" were available, it was almost impossible to extract the decision-making method from the experts. The experts could perform the diagnosis, but they could not explain how they did it. They had difficulty describing in concrete terms the steps taken during the on-line, real-world, decision-making process. In a similar way, when writers are asked to explain their writing strategies, they find it difficult to do so because their strategies have become "tacit knowledge" (Polanyi and Prosch, 1975). According to Odell, Goswami, and Herrington, "it is likely that we do not consciously formulate much of this knowledge as a set of premises or maxims, but instead internalize it as inexplicit functional knowledge that we shall use and expand upon each time we write" (221). By examining data from the abstracts themselves, however, we can see the outcome of this "tacit knowledge" in the organizational elements, both structural and stylistic, that this group of writers finds so hard to describe.

The anecdotal evidence mentioned above about the amount of thought and planning these scientists and engineers give to their abstracts distinguishes two basic types of "expert" abstract writers in this group: the majority (eight of ten) are not overtly aware of how they write abstracts; the minority, on the other hand, "prefabricate" their abstracts from other parts of the report. Comments from either type of writer, however, have at least one thing in common: there is no mention of any external source as a guide for writing abstracts. Yet when the abstracts themselves are examined, a number of common structural and stylistic elements can be isolated, as will be seen in Chapter Three.

There appear to be several reasons why these writers do not reference any outside source for structuring their abstracts. First, these technical and scientific writers have not been exposed to information about the importance of abstracts. Their primary exposure has come from the technical journals to which they submit their articles for publication. Most technical journals state their requirements for publication in a brief section called "information for authors." As Chapter 2 will show, "information for authors" generally includes only the barest of requirements for abstracts, such as a statement about being brief or about the maximum number of words allowed and very little else. Thus, it may appear that abstracts are not viewed by these journals as important.

The second reason these technical and scientific writers do not acknowledge advice from a textbook or from a journal source is that writing an abstract for a journal, because the requirements are minimal, may demand only the most rudimentary plan. Journal requirements for abstracts allow the writer a great deal of flexibility and, since these writers have gained detailed knowledge of their topics from extended study and from close observation, the condensed statements about their deeply familiar topics are likely to conform to the logic of the topic itself. As Chapter Three will show, abstracts tend to follow the rhetorical arrangement of the experiment or procedure being described in the report. This sense of connectedness of real world writers to their writing projects may also help to explain why it is difficult to get writers in a classroom to write suitable abstracts. Writing an academically based abstract about a topic that is artificially constructed and is relatively remote from any real interest to the writer can be much more difficult than writing an abstract on a topic of keen professional and possibly personal interest.

A third reason these writers do not mention outside sources may be that as scientists and engineers themselves, they know what their fellow scientists and engineers are looking for in an abstract. As will be shown in Chapter Four, that need is met by including a description of the scope of the project or experiment in the abstract.

THE REPORTS

The reports for this study were gathered from research papers submitted during 1990 and 1991 for publication in scientific and engineering journals from the R&D Division of a large manufacturing company. The 48 documents for this research were eventually published with the abstract at the head of the full text in either a journal or in the proceedings of a technical conference. Thus, they can be considered successful models of real-world technical writing as judged by practitioners.

These reports deal with topics such as corrosion, metal fatigue, water chemistry, and the properties of various types of coal. Most of the reports were written to be published in the proceedings of societies, such as the Electric Power Research Institute, the Society of Photo-Optical Instrument Engineers, the American Nuclear Society, and the National Association of Corrosion Engineers. Some of these reports were also presented as technical papers at annual conferences, such as the International Conference on Coal and Slurry Technology, the International Joint Power Generation Conference, the Cryogenic Engineering Conference, and the Joint Army-Navy-NASA-Air Force Conference and then published in the Conference Proceedings.

In addition, some of these reports were presented at university sponsored conferences, such as The University of Pittsburgh Coal Conference and the 1991 Incineration Conference sponsored by the University of California, Irvine. Papers were also written for international conferences sponsored by such groups as the French Society of Nuclear Engineers and the National Natural Science Foundation of China. Finally, some of these reports were published in technical journals, such as Materials Evaluation, and specialized publications, such as Coal Retrofitting and Repowering for Future Use (see the Appendix for a complete list of the titles of the reports and where those reports were published).

THE TEXTBOOKS

Thirteen well-known technical writing texts were selected for this study from major publishing houses that supply colleges and universities with textbooks: Bobbs-Merrill, Harcourt Brace Jovanovich, Holt Rinehart and Winston, Houghton Mifflin, Macmillan, McGraw-Hill, Prentice-Hall, St. Martin's Press, Scott, Foresman, and Wadsworth. The textbooks examined for this study are:

1. Andrews and Blickle, Technical Writing: Principles and Forms, 1978.
2. Ron S. Blicq, Technically-Write!: Communicating in a Technological Era, 3rd ed., 1972.
3. Rebecca Carosso, Technical Communication, 1986.

4. Damerst and Bell, Clear Technical Communication: A Process Approach, 1990.

5. Frances Emerson, Technical Writing, 1987.

6. Houp and Pearsall, Reporting Technical Information, 6th ed., 1984.

7. John Lannon, Technical Writing, 5th ed., 1988.

8. Michael Markel, Technical Writing: Situations and Strategies, 2nd ed., 1988.

9. Mathes and Stevenson, Designing Technical Reports: Writing for Audiences in Organizations, 2nd ed., 1976.

10. Mills and Walter, Technical Writing, 5th ed., 1986.

11. Olsen and Huckin, Technical Writing and Professional Communication, 1991.

12. Theodore Sherman, Modern Technical Writing, 2nd ed., 1966.

13. Charles Stratton, Technical Writing: Process and Product, 1984.

In addition, two texts, the Handbook of Technical Writing, 3rd revised edition, by Charles T. Brusaw, Gerald J. Alred, and Walter E. Oliu (published by St. Martin's Press) and How to Write and Publish a Scientific Paper, 3rd edition, by Robert Day (published by Oryx Press) are also included because they are frequently used as texts.

The textbook suggestions from this group about how to construct an abstract can be divided into two main categories: comments on structural characteristics and comments on stylistic characteristics. Discussion of the structural characteristics describes such elements as purpose, scope, methods, results, conclusions, recommendations, and appropriate length. Discussion of the stylistic characteristics includes such suggestions as omit unnecessary words, avoid telegraphic writing, use conjunctions, use cohesive elements, avoid the first person, avoid passive sentences, and avoid jargon.

Briefly, what we know about abstracts from the textbooks can be stated in five axioms:

1. There is a distinction between an abstract that describes what the document is about and an abstract that describes what the document contains.

2. Regardless of type, all abstracts should be written to stand alone.

3. The abstract is often considered to be the most important part of a report.

4. The abstract is often read as a substitute for reading the entire document.

5. Conciseness is of paramount importance.

THE JOURNAL GUIDES

In addition to considering what standard technical writing texts have to say about writing abstracts, this dissertation will explore non-textbook sources. Technical writers can find requirements for the format and length of abstracts by consulting various "authors' guides" published by scientific and technical journals. A primary source of information for the authors of technical papers is "Information for IEEE Transactions and Journal Authors," published by The Institute of Electrical and Electronic Engineers (IEEE). Many of the 48 reports used in this study were published in an IEEE journal or proceeding. Other journals consulted for details on writing abstracts are:

- Journal of Solid-State Circuits
- Optoelectronics
- The Journal of The Minerals, Metals & Materials Society
- Journal of Magnetic Resonance
- International Journal of Heat and Mass Transfer
- International Journal of Fracture
- Journal of Fluids Engineering
- Earthquake Engineering and Structural Dynamics
- Journal of Fluids Engineering
- Computers and Structures
- Journal of Pipelines
- International Journal of Soil Dynamics and Earthquake Engineering
- International Journal for Numerical Methods in Engineering

The guidelines in these journals are, of course, specific to each journal's format. Taken as a whole, however, they provide only limited guidance for the technical writer. Overall, the suggestions found in these journals agree with three of the five axioms for structuring abstracts that were suggested by the textbooks:

- regardless of type, all abstracts should be written to stand alone,
- the abstract is often read as a substitute for reading the entire document,
- conciseness is of paramount importance.

The journal guides do not mention the two additional elements found in the textbooks:

- there is a distinction between an abstract that describes what the document is about and an abstract that describes what the document contains,
- the abstract is often considered to be the most important part of a report.

This difference in point of view between the textbooks and the journal guides is significant. It underscores the fundamental difference between writing in the academic world and writing in the non-academic world. Distinctions such as labeling the abstract, which the textbooks spend much time discussing, are of little importance to the journals. The format of the abstracted information is of less importance to the journals than is the substance of the abstract. Obviously it is in the nature of a textbook to instruct by discussing form, structure, style, and so on, and therefore the terms used to differentiate the types of abstract are important to the textbooks. But among the journals mentioned above, the differentiation of terms is not mentioned. Brevity, accuracy, and comprehensibility take precedence over form. A more detailed look at the textbook suggestions for abstracting documents and at the journal requirements for abstracts of articles will be found in Chapter Two: Textbook, Article, and Journal Recommendations. In Chapter Three: Materials and Methods, each abstract from the 48 reports will be analyzed for the following elements:

- structural composition (including purpose, scope, methods, results, conclusions, and recommendations), stylistic selections (including the use of cohesive elements, first person, passive voice, jargon, abbreviations, parallel structure, and telegraphic writing), length (including sentence length as well as overall abstract length),
- patterns around which the abstract is arranged (including whether it primarily employs as an organizing pattern a narrative focus, a definition of terms, a statement of facts, or a statement of results).

Chapter Four will present the results of this analysis and discuss the data according to the categories above. Conclusions and implications from these results will be discussed in Chapter Five.

CHAPTER TWO

TEXTBOOK, ARTICLE, AND JOURNAL RECOMMENDATIONS

This chapter will first discuss recent research in nonacademic technical writing tracing two major themes: the attempt to find single source solutions and studying workplace constraints on writing choices. The chapter will then briefly describe four categories of suggestions found in the technical writing textbooks for structuring abstracts (type of abstract, style, structure, and length). Finally, the chapter will present a more in-depth discussion of the textbooks and journal guides to get a benchmark for evaluating the 48 abstracts in Chapter Three.

RESEARCH IN NONACADEMIC WRITING

It has become clear to scholars of technical writing in recent years (Bazerman and Paradis, 1991, Barabas, 1990, Odell and Goswami, 1985) that writing in the corporate world is quite different from writing in a university environment. Indeed, whenever writers make the transition from the academic world to an industrial setting they must master "new ways of speaking, reading, and writing, ways that are appropriate within each community" (Berkenkotter, Huckin, and Ackerman, 1991, 192). The call for studying nonacademic writing is stated in several ways. Odell, Goswami, Herrington, and

Quick (1983) emphasize that we should study writing in its natural setting and "not rely solely on teacher-designed, experimental tasks. We should be concerned with the writing tasks people actually do as a normal part of their day-to-day work" (18). The authors conclude that nonacademic writers have no single source or clear guidance for the choices they make about audience, persona, and subject matter. As we will see in this dissertation, writers have no single, clear source for guidance in writing abstracts as well.

Nevertheless, there are continuing attempts in recent research to discover a single source solution for writing choices. Flower, Hayes and Swarts (1983) use protocol analysis to attempt to provide some sort of single source or "consistent pattern" which writers can use for revising documents. They conclude that a "scenario principle, which states that revisers should structure information around 'human agents' performing 'actions' in particularized 'situations,'" (55) can, in some cases, be used as a guideline for revising documents. The authors add, however, that "this study raises a provocative question: how far should we generalize the value of the scenario principle?" (56). The elusiveness of the task of pinning down a single source of guidance for any part of the writing process is apparent. Their answer is that "perhaps scenarios are simply a way people translate any sort of difficult prose in an attempt to make it comprehensible" (56).

Winkler (1983) attempts to reduce the complexities of writing by using models as analogues. Inventional models can illuminate the writing process, while structural models (problem statement, literature review, discussion, etc.) can show the format for the writing product. She emphasizes, however, that when models are used in a classroom, "these models do not guarantee success; they simply increase the writer's chances of consistently producing more effective discourse" (120). Complexity and elusiveness seem to be the constants of studying the writing process. As Selzer says "we obviously have a lot more to learn before we can reduce the complexities of technical writing to reliable maxims" (1983, 85). Even readability formulas, which were at one time widely used as writing guidelines for government, military, and industry documents, have met with what Huckin calls "widespread dissatisfaction" because "readability formulas are designed to measure only superficial linguistic variables" (1983, 90). Huckin cites research in cognitive psychology as adding the necessary depth and substance to readability formulas. Such research is "directly relevant" to writing researchers because it is consistent with the second major theme above, studying "connected discourse." As Huckin says, studies of connected discourse represent "original empirical research, with large numbers of test subjects, reasonable controls, and, most importantly, lengthy examples (full paragraphs and more) of prose discourse" (92).

The two major themes are again reflected by Harris (1983) when she states that "extending and systematizing our knowledge of technical writing would seem to require attention to its discourses from perspectives essential to their constitution as such" (155). In addition, she finds that treating technical and scientific writing as a topic to be studied "scientifically" is an appropriate method for achieving more effective discourse. Harris uses semiotically-based discourse theory (syntactics, i.e., signs and their relationships with other signs; semantics, i.e., the signs' referents; and pragmatics, i.e., the signs' use by interpreters of those signs) in the continuing attempt to show "the value of systematizing knowledge about the objects of our interest" (154).

Dobrin attempts much the same thing by defining technical writing as "writing that accommodates technology to the user" (1983, 242). In explaining his definition, Dobrin incorporates studying documents procedurally into the theme of studying workplace constraints on nonacademic writing. The procedure in technical writing, he says, "begins where someone conceives the need to accommodate," and ends "where the accommodation is completed." Looking at technical writing as a procedure enables us to "look at each thing in its domain." For those studying technical writing in this fashion, however, there are certain drawbacks. Studying a procedure, as Dobrin says, "is very difficult, for penetrating groups which you are not a member of requires learning a new way of thinking.

It is likely that this new way will not be easy to generalize" (248). For example, Berkenkotter, Huckin, and Ackerman (1991) examine a case study by Myers of two biology students revising papers according to their referees' suggestions. The question Myers raises in his research is a familiar one to this study: "How does a researcher learn all [the] complex conventions of the scientific article?" (211). The answer to his question is, again, complex and elusive. It involves "the ability to adapt one's discourse as the situation requires" (211). Adapting to the constraints of the workplace seems to be, in fact, what all nonacademic writers must do on a day to day basis as they receive writing assignments from their superiors.

Bazerman and Paradis (1991) caution that workplace constraints must be considered in writing studies, and that "the textual autonomy associated with the library fails in the workplace, where textual dynamics are a central agency in the social construction of objects, concepts, and institutions" (4). The authors raise further questions about nonacademic writing constraints, questions that this dissertation will discuss in Chapter Five.

Herndl, Fennel, and Miller (1991) review the infamous workplace constraints of companies involved in the Three Mile Island and the Challenger disasters. Their conclusion "illustrates the complexity of the current term 'discourse community.' Since the relationships between language use and social structure are various and are describable with different analytical methods, the term discourse community becomes either misleadingly vague or intriguingly rich" (304).

The vagueness and richness of undertaking such a study of nonacademic writing is well documented by Paradis, Dobrin, and Miller (1985). The authors found three elements that make studying writing in nonacademic settings difficult: first, there is a lack of consensus about the purpose of writing, the features of good writing, or the procedures for preparing documents; second, it is difficult for writers to discuss and explain their individual writing techniques; and third, employees feel uneasy about the amount of time they spend on writing tasks. In a corporate setting where the level of activity is often a measure of an employee's contribution, the authors found that writers were "uncertain about the legitimacy of writing as a work activity." Writing, in short, was not "widely recognized as a key work activity" (286)

There is evidence, however, that some maxims about nonacademic writing can be drawn from certain studies, and that those maxims can apply equally well to a larger community. In engineering writing, for example, Selzer (1983) has identified two generalities from examining a specific engineer that seem to be applicable across other technical disciplines. Writers in business and industry, Selzer says, first nearly always write in response to some specific request either for a proposal to do work, for a report on the work's progress, or for a final report; and second, write certain kinds of documents repeatedly (179). These two realities for technical and scientific writers are certainly the case for the authors of the reports used in this study. Since these writers must keep management informed through periodic progress reports, they not only write the same kinds of documents as far as format is concerned, but they write documents repeatedly about the same subject matter. They are hired as technical experts in a fairly specific field and are paid to communicate their knowledge to a wider audience both internally to upper management and externally to potential customers. Because they repeatedly write the same kinds of documents, their strategies for abstracting information from those documents, as seen from the anecdotal remarks in Chapter One, become second nature and are hard to define.

Finally, many of the issues discussed above are explored at length by Barabas (1990). Her wide-ranging topics include the theoretical background of the themes above, as well as actual evaluations of progress reports written for industry. She notes that "research on real-world business and technical writing is yet in its infancy," and therefore "requires more innovative, exploratory research than we have become accustomed to doing" (170).

In consort with the these themes, this dissertation attempts to understand more about one aspect of how writers in the non-academic world go about their work. By examining the complete abstracts from documents of a group of practicing technical and scientific writers, we can isolate the elements that made up successfully published abstracts for them. We will next examine what suggestions technical writers can find in a selection of textbooks used in university technical writing classes.

GENERAL THEMES OF THE TEXTBOOKS

Type of Abstract

Abstracts are mentioned in virtually all technical writing textbooks in one form or another. Although there were several "common" suggestions found among the fifteen textbooks selected for this study, there were no "universal" suggestions found. What to call the abstract was the most debated issue. The two basic types of abstracts are generally called "descriptive" and "informative." Broadly speaking, the descriptive abstract is the shorter of the two and essentially lists in paragraph form the topics covered in the report. The informative abstract, on the other hand, can be more than one paragraph and usually discusses the report's results as well as any new discoveries made.

Several texts, including Damerst and Bell, Brusaw, et al., and Andrews and Blickle define the descriptive abstract as a prose table of contents. Thus, a descriptive abstract "describes" the report's contents, while an "informative" abstract provides abbreviated facts and details, key findings, as well as some results and recommendations. A clear idea of when it is appropriate to write a descriptive abstract and when to write an informative abstract, however, is quite difficult to gather from the texts, except for the general suggestion that it depends on audience needs.

Three texts, Andrews and Blickle, Mathes and Stevenson, and Emerson, use "indicative abstract" instead of the more common term, "descriptive abstract." In some cases, textbooks collapse the definitions of "summary" (used at the beginning of a report) and "abstract." Although summary and abstract are seen as being nearly identical in some texts, the subject matter of the report seems to determine which term to use: if the report is scientific or technical, the condensed description of that report is called an abstract; if the report covers a financial or business topic, the condensed version is called a summary; if the report is to be published in a journal or a conference proceeding, regardless of topic, the condensed version is called an abstract.

The lack of consistent terminology for abstracts has been a problem throughout the textbook review. Sherman, like Blicq, calls the informative abstract the "summary." Sherman also mentions "forward" and "digest" as optional terms for abstracts. "Indicative abstract" is used by four texts: Andrews and Blickle, Mathes and Stevenson, Emerson, and Day. Andrews and Blickle, however, use "topical abstract" in place of descriptive abstract. Stratton introduces "precis," "brief," and "synopsis" to the list and adds "evaluative abstract" for an abstract of a research report. Carosso discusses "executive summaries" with abstracts. Mills and Walter use "informational abstract" for "informative abstract," but add that if the abstract is a short one, it can be called an "epitome." Finally, Damerst and Bell offer "topical abstract" for "descriptive abstract." Table 1--Summary of Textbook Terms for Abstracts lists these terms and the texts that use them.

In some cases the difference between the textbook descriptions of the descriptive and the informative abstract seems to depend on whether the abstract contains some mention of the results of the research. In other cases the only difference between the two is that the report's scope is left out of the descriptive abstract. This distinction contradicts what was found in the 48 abstracts examined for this study, since scope occurred as a structural element in 46 abstracts, regardless of the type of abstract or the type of journal in which it was published.

TABLE 1 - SUMMARY OF TEXTBOOK TERMS FOR ABSTRACTS

TYPE OF ABSTRACT		DESCRIPTIVE ABSTRACT	COMBINED DESCRIPTIVE AND INFORMATIVE ABSTRACT	INFORMATIVE ABSTRACT	OTHER
1. Sherman	1966	Abstract	None	Summary	None
2. Blicq	1972	Abstract	None	Summary	None
3. Andrews & Blickle	1978	Topical	Indicative	Informative	None
4. Stratton	1984	Descriptive	Evaluative	Informative	Summary, Precis, Brief, Synopsis
5. Mills & Walter	1986	Descriptive	None	Informational	Epitome
6. Brusaw, Alred, & Oliu	1987	Descriptive	None	Informative	None
7. Carosso	1987	Descriptive	None	Informative	Executive Summary
8. Emerson	1987	Indicative	None	Informative	None
9. Houp & Pearsall	1988	Descriptive	None	Informative	Summary
10. Markel	1988	Descriptive	None	Informative	None
11. Day	1988	Indicative	None	Informative	None
12. Damerst & Bell	1990	Topical	None	Informative	None
13. Mathes & Stevenson	1991	Indicative	None	Informative	None
14. Olsen & Huckin	1991	Abstract	None	Abstract	None
15. Lannon	1991	Descriptive	None	Informative	None

Although much space is devoted in the textbooks to outlining these differences, it appears that the distinction is an academic and artificial one. When the 48 abstracts themselves were examined, as will be discussed in Chapter Three, there was no evidence of a clear distinction in whether the abstract was informative or descriptive. In addition, no mention of the types of abstracts is found in any of the technical journals consulted, or in the authors' guides to those journals. Many of the textbooks, taken individually, provide good advice to the reader on how to format, organize, and even edit the abstract, but the discussion about type seems to be a textbook debate, not one related to abstracts published outside the academic world. A more detailed discussion of the individual textbook comments on the types of abstracts follows in the "Discussion of the Textbooks" section.

Style and Structure

In addition to the debate over what to call the abstract, two general themes can be isolated from the texts, one describing suggestions for "style" and the other describing suggestions for "structure." The eleven stylistic elements based on the suggestions mentioned most frequently in the texts are discussed below. The structural elements suggested by the texts are: "Purpose or Need," "Scope," "Methods," "Results," "Findings," "Conclusions," and "Recommendations."

Style

Eleven stylistic elements are suggested by the textbooks for writing an abstract:

1. eliminate unnecessary words
2. however, avoid "telegraphic" style by not eliminating articles and cohesive elements
3. use conjunctions for proper subordination
4. write in complete sentences
5. make sentences active
6. use parallel structure
7. spell out acronyms
8. use only the most common abbreviations.
9. avoid jargon except when it is common to the field of study
10. avoid the first person
11. make sure the abstract makes sense without reference to the report.

Some texts do not mention style at all as an element in writing the abstract and some discuss style at length. Authors who do not mention style are Markel, Mathes and Stevenson, Olsen and Huckin, and Houp and Pearsall (although Houp and Pearsall refer the reader to a section on "style" for writing the "summary"). Sherman gives the abstract writer several stylistic suggestions that are representative of many of the textbooks' comments: use minimal technical information, eliminate unnecessary words, and avoid jargon and abbreviations. Two of these elements, eliminating unnecessary words and avoiding jargon are also mentioned by Lannon and Mills and Walter. Lannon encourages the abstract writer to translate all technical data, and to use cohesive elements as well. Some authors, however, such as Andrews and Blickle as well as Damerst and Bell, say that using jargon in the form of familiar abbreviations is acceptable. Andrews and Blickle also state that the abstract writer should avoid unnecessary words, avoid telegraphic writing, and use participles.

Damerst and Bell agree that the writer should avoid unnecessary words and telegraphic style, and they say to be sure to use cohesive elements. The only suggestion on style made by Markel is that using jargon, which he calls "technical terminology," is acceptable. Brusaw, Alred, and Oliu discuss all the elements mentioned above, and they add that the abstract writer should use proper subordination, cohesive elements, and parallel structure. Some jargon use for Brusaw, et al., is acceptable. Finally, two other suggestions for style are mentioned: an abstract writer should never use the first person (Houp and Pearsall, and Sherman) and the writer should use active voice (Andrews and Blickle). In contrast to this last suggestion and to the suggestions of many other technical writing texts about using active voice, almost 46% of the sentences in the abstracts in this study were passive. Since this constitutes a major finding of this dissertation, a brief review of the literature on passives follows.

The literature on passive sentence construction offers some reasons to modify the call for using active voice. The value of passive constructions is discussed by Levinson (1983). He states that language has the ability to allow for the active-passive choice "for the purpose of meshing sentence-construction with pragmatic principles" such as "foregrounding" and "backgrounding" the informational content in a sentence (41). Writers are able to control the way readers process information by the "linear reorganization of the material in sentences" (41). Using a passive construction can place the emphasis on the project or on the experiment itself rather than on the writer or the performer of the experiment. Readers' knowledge of the world includes knowing that researchers and experimenters carry out the work. The work is, therefore, the focus or topic rather than the agent who carried out the work. When the work is topicalized, the agent is truncated, and thus the agentless passive form appears accordingly. Making the topic of the sentence coincide with the first noun in the sentence can guide the reader to the appropriate focus the writer intends. "Fronting" a lexical item in this fashion in a sentence controls the way the reader interprets the remaining information in the sentence (Witte and Cherry, 1986, 128). As an example, Witte and Cherry provide a brief narrative with three different endings:

- Paul struck the bell with a stick.
- The bell was struck by Paul with a stick.
- A stick was used by Paul to strike the bell (128).

The passive constructions in the second and third sentences change the topic of the sentence and can bring to the foreground the information the writer deems important.

Use of this "topical focus" provides the reader with several advantages. The reader can construct the "gist" of the abstract by connecting the topic with information stored in the reader's memory, and, thus, can be prepared for all of the "new" information to follow in the abstract. The abstract writer, however, depends on the reader to have sufficient "given" information about the topic stored in memory in order to construct the "gist" of the abstract. "Given" information, as defined by Chafe

(1976), is "that knowledge which the speaker assumes to be in the consciousness of the addressee at the time of the utterance" (30). "New" information is defined as "what the speaker assumes he is introducing into the addressee's consciousness" (30). Vande Kopple (1986) further defines these terms based on the idea of "shared knowledge": "given information is that which a speaker or writer assumes that the addressee knows, assumes, or can infer. New information is that which a speaker or writer assumes that the addressee does not know, does not assume, or cannot infer" (78).

The reader makes use of "given" and "new" information by dividing a sentence into the appropriate informational categories, and then looking for an antecedent in memory (Clark and Haviland, 1977). From that antecedent, which is found in one of the reader's many mental "schemata" (Rumelhart, 1980), also called "scripts" (Schank and Abelson, 1977), "scenarios" (Sanford and Garrod, 1980), or "frames" (Minsky, 1975), the appropriate schema is evoked to provide the context necessary for understanding the text. When a reader begins to read an abstract, evoking the appropriate schema is crucial to being able to comprehend the compressed information that follows. The reader evokes the "schema," "frame," or "script" by using a "keyword" to activate the information stored in memory (Garnham, 1985, 167). Since the topics in these technical and scientific abstracts are highly specialized and the reports they accompany are written for a specialized audience, writers of these abstracts can assume that their readers will already have a significant amount of "given" information, or "shared knowledge." Lack of knowledge about the topic, however, "may make a text more difficult to understand, particularly if it prevents a bridging inference from being made" (Garnham, 169). To provide readers with the easiest path to accessing the appropriate context, then, writers will unwittingly use passive constructions, which place the topical focus of the sentence on the logical object and delete the given information (the agent). Thus, the reason so many passives in the corpus lack the agent is because the writer knows that the readers know that experiments are done by researchers, and it is the experiment, not the researcher, that is important to the reader. As will be discussed in Chapter Five, the abstract writers of these 48 abstracts frequently use passive sentence constructions to produce their abstracts.

In general, then, the suggestions about style found in the technical writing textbooks range from being laissez faire to being prescriptive. Some texts discuss style in the report writing section of the text and do not repeat that discussion in the section on abstracts. Other texts do not assume that the reader has read other sections and discuss style even though it has been discussed at length before. The information collected about stylistic elements suggested by the textbooks is discussed further in Chapter 3.

Structure

Textbook recommendations about structure are somewhat more consistent than are the recommendations about style. The structural elements most often mentioned by the textbooks are:

- purpose (sometimes called "issue" or "need") - which describes the problem or need for the report
- scope - which outlines the steps taken during the project or experiment
- method - which describes procedures used, especially if they depart from what is customary
- results (sometimes called "findings") - which state what the report says that is new
- conclusions - a brief evaluation of the results, which include inferences or comparisons
- recommendations - for future research or for the application of the process described in the report.

Fourteen texts recommend including conclusions in the abstract, eleven recommend a statement of purpose, ten suggest recommendations, nine recommend a statement of methods, seven suggest results, and six recommend scope. Although almost all the texts place a high priority on stating the purpose and recommendations in the abstract, this priority is not reflected in the 48 abstracts examined for this study. A purpose statement was the second most frequently suggested structural element by the textbooks, yet it occurred in only ten abstracts. Recommendations, the third most frequently suggested structural element occurred in only four abstracts. Scope, however, which was suggested by only six texts, was found in 46 abstracts. These differences are discussed more fully in Chapter 4.

Andrews and Blickle, Brusaw, et al., and Markel present the most thorough discussion among the textbooks about structural elements. These texts state that the abstract needs to include a purpose statement, scope, methods, results, findings, conclusions, and recommendations. On the other hand, Sherman does not mention structural elements at all, while Damerst and Bell as well as Houp and Pearsall only mention that the abstract should include conclusions and recommendations. Lannon states that, besides conclusions and recommendations, an abstract must contain a statement of need and should also report findings. Mills and Walter omit methods and results from their discussion, but include scope in the list of necessary structural elements. Although Mathes and Stevenson as well as Olsen and Huckin do not mention scope, they do discuss purpose, methods, results, findings, conclusions and recommendations.

Several texts mention elements to be avoided, such as a detailed discussion of the background and the methods used, as well as any tables, figures, charts, maps, or bibliographic references, and any information not in the original report. The information collected about structural elements suggested by the textbooks is discussed further in Chapter 3.

Length

Many of the texts in this review are quite specific about abstract length. The numbers vary from text to text, but, in general, abstract writers are requested to stay within two ranges: fewer than 250 words and less than 10% of the total report length. Only two texts did not specifically mention length (Lannon, and Olsen and Huckin). The suggested limits are as follows:

- Andrews and Blickle - 6% or 150 to 300 words
- Blicq - 125 to 250 words
- Brusaw, Alred, & Oliu - 200 to 250 words
- Carosso - one paragraph to one page

- Damerst & Bell - 10% of the report length
- Day - 250 words
- Emerson - a single page
- Houp & Pearsall - 5% to 10% or fewer than 200 words
- Lannon - no length mentioned
- Markel - fewer than 200 words
- Mathes and Stevenson - 100 to 250 words
- Mills and Walter - 5% of the report length
- Olsen and Huckin - no length mentioned
- Sherman - 10% of the report length

DISCUSSION OF THE TEXTBOOKS

The 15 textbooks selected for this study present a full sampling of technical writing texts published by major publishing houses over the last four decades. Most of the texts are mentioned in Souther's retrospective appraisal (1989). Below is a chronological discussion of this selection of standard classroom texts published between 1966 and 1991. Although no attempt has been made in this dissertation to analyze how attitudes about abstracts may have changed in the second half of this century, that question remains for further research and may, indeed, suggest a method for tracking the evolution of technical writing as a discrete academic field as well as a separate occupation in industry.

Sherman (1966) combines the discussion of abstracts with summaries. The reason for combining the two, in this case, is one of terminology. What some texts call the "descriptive abstract," which is the briefest form of an abstract, Sherman simply calls the "abstract." What some texts call the "informative abstract," however, Sherman calls the "summary." "The problem of discussing summaries and abstracts," Sherman says, "is complicated by the lack of anything approaching a general agreement about terminology" (192). The problem is further complicated, he says, because at least two other terms, foreword and digest, are also used in place of "abstract" (193).

Regardless of the terms used, Sherman stresses the importance of the abstract. He notes that "no other section with the possible exception of conclusions and recommendations is more important" (193). The reason, he says, is that "you may expect that it will be read more frequently, read by more people, and read by more important people than will the full report" (194). Sherman mentions five additional reasons for writing a good abstract:

1. The writer's superior may read the abstract and little else.

2. Readers who do read the entire report may later refer to the abstract to refresh their memories.

3. Readers may use the abstract to decide to read the full report.

4. The abstract may be distributed in a company so that other departments may see what information is available.

5. The abstract may be kept in an indexed file to avoid needless duplication of future reports (194).

Recommendations for composing the abstract from Sherman are quite specific. He states that reading a few lines and then summarizing them, reading a few more, summarizing, and so on, will be "ineffective." Rather, he suggests, the writer should first go over the report one entire section at a time making notes, next write a rough draft, then polish to read as smoothly as possible without the "waste of space on introductory and transitional material" (194). The writer should also leave out such elements as "preliminaries, details, illustrative examples - everything except the main facts and ideas" (194). The length should be no more than 10% of the entire report. The abstract should contain no information that is not in the original, and technical vocabulary should be held to a minimum. Finally, "little if any use is made of the first and second person" (226).

According to Blicq (1972), the abstract is considered to be the most important part of a report as well as the most difficult to write. It is difficult to write because although it must be compressed, it must be clear, and it must use the appropriate amount of technical terminology for the audience. Like Sherman above, Blicq also discusses the differences between the abstract and the summary. According to Blicq, the major difference is determined by use of technical terminology. Readers of a summary may have less technical knowledge than readers of an abstract, and therefore a summary should contain few technical terms. Readers of an abstract, however, should be more familiar with the terminology of the scientific or technical discipline of the report, and therefore jargon use is acceptable. Other than jargon, Blicq says that abstracts and summaries are "almost identical," except that the abstract emphasizes results. In contrast to Blicq, however, Carosso below states that the purpose of the abstract is to condense the document, while the purpose of the summary is to emphasize results, conclusions and recommendations. In general, Blicq says the ideal abstract length is 125 words, and should never be more than 250 words. The abstract should emphasize the results of the study and the writer should:

1. outline the problem and the purpose of the investigation

2. mention very briefly how the investigation or tests were conducted

3. describe the main findings

4. summarize the conclusions that have been drawn.

Andrews and Blickle (1978) use a separate chapter to discuss abstracts. The authors repeat the usefulness of abstracts stated in Sherman above, but add that abstracts can also be used to inform colloquia participants of what meetings to attend and suggest ideas for what questions they might ask.

The authors make the same distinction between the "informative abstract" and the "descriptive abstract" that was made in the "Types of Abstract" section discussed above; however they add two more terms: the "topical abstract," which they substitute for "descriptive abstract" (178), and the "indicative abstract," which they use when elements of the descriptive abstract and the informative abstract are mixed (181).

As for the details of structuring the abstract, Andrews and Blickle also are fairly specific. The first sentence should state the objective of the report, followed by a statement of the scope. Next should come a statement of results, the theoretical or experimental plan, the procedures, the basic principles involved, operational ranges, and the degree of accuracy attained

(182). The writer should think of the abstract as a prose form of the table of contents.

The writer should use only familiar abbreviations and avoid technical jargon. Verbs, conjunctions and articles should be included, and the writer should avoid short, choppy sentences or "overlong" sentences. Also, proper subordination should be used. "Important new quantitative" data should be highlighted in the abstract. This is a recommendation that is not found in other texts. The length should not exceed 6% of the original length, and should be between 150 and 300 words.

Like other texts in this study, Stratton (1984) begins his discussion defining terms. However, he tells the writer, "don't worry too much about whether what you're writing is 'really' an abstract, a summary, a precis, a brief, or a synopsis (there's precious little agreement, anyway)" (232). Stratton states that the "descriptive" abstract is "the thing most people mean when they say 'abstract'" (233).

Stratton defines a descriptive abstract as a short (100 or 200 word) summary written to accompany an author's own report. Among the suggestions for writing the descriptive abstract are:

- write the abstract last
- be sure it is self-contained

- avoid jargon
- start with a one sentence summary of each major section of the report.

The informative abstract, on the other hand, is usually longer than the descriptive abstract. According to Stratton, the informative abstract is typically 2% to 10% of the length of the report. It is prepared to accompany reports written by others. The writer should start with a brief descriptive abstract of the entire work and then compose the informative abstract by noting the significance of the information in the report (234).

In addition to the various types of abstract that we have seen so far, Stratton adds another type, the "evaluative abstract" (234). An "evaluative abstract" is an informative abstract written by a member of a research team. According to Stratton, the "evaluative" abstract includes:

- an evaluation of the quality of work done
- the significance of the findings
- the pertinence of the information to the research team.

Although abstracts and summaries are similar, as we have seen in several of the texts reviewed so far, Carosso (1986) states that they are not identical. Abstracts are concerned with condensing the document's essential information, while summaries are more concerned with "emphasizing results, conclusions and recommendations" (339). In her chapter on "Abstracts and Summaries," Carosso distinguishes among "descriptive" abstracts, "informative" abstracts, and "executive summaries." The distinguishing characteristic among these types is "point of view": the descriptive abstract has an "external perspective" that describes what the document is about while the informative abstract and the executive summary both take "the document's point of view" and provide actual content from the document (342-343). Carosso, like Stratton, states that the writer should not be concerned with what to call the abstract. The writer's concern "should be to learn the purpose and structure of various types of abstracts and summaries rather than worrying about inconsistencies in labeling from journal to journal or organization to organization" (343).

Occasionally, she says, a document will be lengthy enough to require both a descriptive and an informative abstract. In that case, some journals will call a summary what she calls a descriptive abstract. Regardless of the terms used, Carosso says, abstracts should provide an overview "without interpretation," and should present information in the following sequence:

purpose or rationale of the study, methodology, results, and conclusions (340).

Mills and Walter (1986) mention the two types of abstracts we have seen above, but call them "descriptive" and "informational." Abstracts are seldom of purely one kind or the other, they say, but usually a combination of both. In addition, they mention that "epitome" is sometimes used as the term for a short abstract. The rule of thumb for length here is 5% of the length of the report, although they suggest that the abstract not exceed one page. To write the abstract the authors suggest that the writer compose a brief summary of each one of the major divisions of the full report. Those divisions should be: problem, scope, findings, conclusions and recommendations (68). Only familiar abbreviations should be used and definite articles should not be omitted. Unfamiliar technical terminology should be avoided and the abstract should be regarded as completely independent of the report. The authors remind the writer to bear in mind that readers know nothing, except what the title announces about the document. Since abstracts may be published independently of the main document, Mills and Walter caution that abstracts will make no sense if they refer to tables or illustrations in the document, and, therefore, must make no such references.

Brusaw, Alred, and Oliu (1987) present definitions and examples in alphabetized format of all the important elements as well as many of the ancillary aspects of technical writing. Like many of the previous texts, The Handbook divides abstracts into the two basic forms, descriptive and informative, but it does not cross reference any optional terminology.

The descriptive abstract is "almost an expanded table of contents in sentence form" while the informative abstract is "an expanded version of the descriptive abstract" (8-9). The difference between these two forms depends on their scope and purpose. The authors make the distinction clear by listing the contents of each type: the descriptive abstract should contain information about the purpose, scope, and methods, and the informative abstract should add to those elements the results, conclusions and recommendations of the study (9).

According to Brusaw, et al., the reason for writing the descriptive abstract instead of the informative abstract, as Andrews and Blickle also mentioned earlier, depends on whether the abstract is to be used in information surveys and conference proceedings. Whichever type of abstract is written, however, an abstract should be no longer than 200 to 250 words. In addition, it should not include the following:

- the background of the study
- a detailed discussion or explanation of the methods used
- administrative details about how the study was undertaken, who funded it, who worked on it, and the like
- figures, tables, charts, maps, and bibliographic references
- any information that does not appear in the original.

The authors suggest that complete sentences be used, but that unnecessary words and ideas be eliminated. The writer should combine sentences by using "subordination and parallel construction" and spell out "acronyms and initialisms and all but the most common abbreviations" (11). The authors further caution the writer not to slip into a telegraphic style by omitting articles and important cohesive elements, such as "however," "therefore," "but," and "in summary."

Emerson's definition (1987) of the "indicative" abstract is similar to those mentioned in two previous texts for the "descriptive" abstract. The purpose of the indicative abstract is to "indicate" the type of information to be found in the report. It should cover the report's purpose, its method, a description of the report's discussion, the key conclusion, and the report's recommendations. The "informative" abstract, on the other hand, should "provide in condensed form all the essential information contained in the report" (342). For the informative abstract, Emerson adds "scope" and descriptions of "key sections" or "special features" to the list of requirements for the "indicative" abstract. The length should be no longer than a page, and the report should use no abbreviations that would not be easily understood. Finally, the abstract should be able to stand alone without any references to the report itself.

In constructing the abstract, Emerson recommends an eight step process that includes: reading the report without any notations; rereading several hours later to highlight important information; paraphrasing each highlighted section; supplying necessary cohesive elements between sentences and paragraphs; then rereading the abstract to determine if it is "self sufficient" (345).

Day (1988) defines the abstract as a "miniversion" of the paper. The abstract briefly summarizes each of the main sections of the paper: Introduction, Materials and Methods, Results, and Discussion. Day discusses the distinction between the informative abstract and the "descriptive" abstract, which he calls the "indicative" abstract. The distinction, he says, is that the informative abstract can serve as a substitute for reading the entire paper and is, therefore, "substantive." The indicative abstract, on the other hand, indicates only the subject of the paper and is, therefore, descriptive rather than substantive.

Day stresses the importance of conclusions and states that conclusions are usually given three times: once in the Abstract, again in the Introduction, and again in the Discussion. The steps he suggests for writing the abstract are:

- state the principal objectives and scope of the investigation,
- describe the methodology employed
- summarize the results
- state the principal conclusion (28).

Also, Day says, the abstract writer should make sure that the abstract is self-contained, making no reference to the paper itself, and be sure not to exceed 250 words.

Houp and Pearsall (1988) use the more common terms of "informative" and "descriptive" abstracts. They say, however, that a report will often have both kinds of abstract. In that case the distinction can be seen by calling the descriptive abstract the "abstract" and the informative abstract the "summary" (209), as did Sherman above. The abstract should be five to ten per cent of the length of the report, but under 200 words, and an abstract writer should never use "I."

To give the reader some perspective of what a journal might require of an abstract, Houp and Pearsall include "Instructions for Abstracting" from the Publication Manual of the American Psychological Association, 2nd Edition. The Manual states that the abstract must be self-contained and include statements of the problem, method, results, and conclusions. If the writer is abstracting a research report, the number, type, age, and sex of the subject population should be specified, and the research design, test instruments, research apparatus, or data gathering procedures that are important should be described. Statistical significance levels should be stated, and inferences drawn from the results should be summarized. Few technical and scientific journals are this specific about the requirements for abstracts in their journals. In fact, as we shall see in the "Journal Guides for Authors" section below, many journals provide authors with no advice other than word length.

Markel (1988) briefly describes the descriptive and the informative abstract, then states that the descriptive abstract is "rapidly losing popularity," and the informative abstract is "becoming the accepted standard" (282). According to Markel, the informative abstract is composed of three basic elements:

1. The identifying information. The name of the report, the writer, and perhaps the writer's department.

2. The problem statement. One or two sentences defining the problem or need which led to the project. Many writers mistakenly omit the problem statement, assuming that the reader knows what the problem is. The writer knows, being intimately involved with the project, but the readers are likely to be totally unfamiliar with it. Without an adequate problem statement to guide them, many readers will be unable to understand the abstract.

3. The important findings. The final three or four sentences, the biggest portion of the abstract, state the crucial information that the report contains.

Generally, this means some combination of results, conclusions, recommendations, and implications for further projects. Sometimes, however, the abstract presents other information. For instance, many technical projects focus on new or unusual methods for achieving results that have already been obtained through other means. In such a case, the abstract will focus on the methods, not the results (283-284).

Damerst and Bell (1990) also distinguish between two types of abstracts. The authors, however, introduce a new term, "topical," to refer to the descriptive abstract. The "topical" abstract is like the table of contents of a report, whereas the "informative" abstract tells "what a report or article is about and what it says" (131). Most of Damerst and Bell's subsequent discussion, which comes under the heading of "Summaries and Abstracts as Clarifying Techniques," is in list form. The authors present lists of the major characteristics of a good abstract, suggestions for writing an abstract, and an additional list of "do's and don'ts." They also include two major characteristics of a good abstract: appropriate length (no more than 10% of the length of the original report or article) and faithfulness to the original in proportion, emphasis, and coverage. As in several of the texts above, the steps Damerst and Bell mention are quite specific and should be followed in order:

1. State in one sentence the central idea of the whole message.
2. Jot down, in a word or phrase, each of the important ideas that point to or support the central idea.
3. Establish tentative links (cohesive elements) for putting these ideas into sentences.
4. Arrange the ideas in the order of their importance, unless you are summarizing a process or a procedure.
5. Establish permanent links to make the sentences complete.
6. Add significant information that was left out because you considered it less important at first.

7. Write a complete draft, using the report's own words wherever possible to give the summary some of the qualities (and flavor and tone) of the original--and for the sake of accuracy.

8. Write additional drafts, always trying to reduce the number of words and to simplify without altering the meaning, proportionate coverage, and emphasis in the original (132-133).

Additional suggested do's and don'ts are also presented in list form:

1. Read the original several times to become thoroughly familiar with it.

2. Estimate the number of words in the original by determining the average number of words per line and multiplying the average by the number of lines.

3. Note the maximum number of words you could use to develop a 10% summary so that you will not use too many words.

4. If the original has good topic sentences, try to shorten them and to add details that support them.

5. Always work to reduce sentences; try to shorten them and to add details to support them.

6. If the abstract must be fairly long because the original includes many important details, use several paragraphs if you cannot logically fit all the information into one. (To save space, professional abstracters usually write single paragraphs. However, some one-paragraph abstracts violate unity and misplace emphasis.)

7. Use Arabic numerals for numbers, however convention dictates that they never be used to begin a sentence.

8. Use abbreviations sparingly. Your audience may expect you to use, say, ppm for "parts per million," but words that are not abbreviated in the original writing - such as experiment-should never be abbreviated in abstracts.

9. Include all articles (a, an, the) and prepositions (e.g., of, by). Phrases, clauses, and sentences must be fully developed in all kinds of writing.

Lannon (1991) also offers detailed comments about composing the abstract. In the chapter on "Summarizing Information," Lannon, like Damerst and Bell, outlines eight sequential steps for properly summarizing a report:

1. read the entire original
2. reread and underline
3. edit the underlined data
4. rewrite in your own words
5. edit your own version
6. check your version against the original
7. rewrite your edited version
8. document your source.

In addition, Lannon tells the writer to add transitional expressions to reinforce the connection between related ideas. This is unlike Sherman's advice, which was to use an exceedingly spare style without transitions.

Like Sherman, however, Lannon gives the writer specific guidelines for writing the informative abstract:

1. Make your abstract able to stand alone in meaning - a mini-report.
2. Write for the general reader. Readers of the abstract will vary in expertise, perhaps more than those who read the report itself; translate all technical data.

3. Add no new information. Simply summarize the report.

4. Present your information in this sequence:
   a. begin by identifying the issue or need that led to the report,
   b. offer the major findings from the report body,
   c. include a condensed conclusion and recommendations, if any.

To show the difference between informative and descriptive abstracts, Lannon uses a "summer travel" analogy: describing the itinerary of the trip, or just the road map, is like the descriptive abstract; adding significant experiences from the trip is like the informative abstract. In short, the informative abstract reflects "what the original contains," and the descriptive abstract reflects "what the original is about" (148).

Designing Technical Reports, 2nd edition, by Mathes and Stevenson (1991), is perhaps the most often cited textbook about writing engineering reports. The authors describe abstracts as having two important functions, that of "accessing information," and that of "informative condensation." The "accessing information" feature may require only the author's name and title, or it may require a format used by an automated storage and retrieval system. For the "informative condensation" feature, Mathes and Stevenson make a distinction between what they call "indicative" and "informative" abstracts.

Like Markel above, Mathes and Stevenson state that the "informative" abstract is generally much more useful to the reader and is the one routinely written. The informative abstract "presents" what is in the report, while the indicative abstract "describes" what is in the report (89).

To clarify what is meant by "presenting" rather than "describing," Mathes and Stevenson give several examples:

- do not say: "The net present values of irrigation agriculture are calculated for two cropping intensities,"

- instead say: "The net present value of irrigation agriculture is $12,000,000 with a cropping intensity of 180% and $23,000,000 with a cropping intensity of 120%" (160).

In addition, the authors state that the abstract is usually 200 words or less and that the writer must be sure to include an "overview of the investigation." The "overview" should explain the problem, method, results, conclusions, and recommendations (221).

Olsen and Huckin (1991) write a separate section to discuss abstracts. The authors give four reasons for writing a good abstract. First, the abstract serves an important function as a "screening device" to let readers know what the report is about. Second, the abstract should be able to stand alone, since abstracts may be used as sources themselves without the necessity of the entire report. Third, the abstract is a "preview" for what is to come in the report. This "preview" function provides the proper "frame" for the main points that are to come in the body of the report. The last function of the abstract is its use to facilitate "indexing." Key words are selected from abstracts to properly cross-index the report in a database or card catalogue.

As for the actual composition of the abstract, Olsen and Huckin say that the abstract goes through four distinct "moves": "The first sentence provides some background information, the second gives a brief idea of the specific topic and methodology, the third reports the major findings, and the fourth draws some conclusions." In addition to these "moves," abstracts typically describe the "methodology used, the main results, and the major conclusions" of the report (368). Occasionally there is also an opening "statement of purpose," or a background statement (367). Finally, the abstract should emphasize major findings and conclusions.

ARTICLES

The articles in this section of the literature review discuss the difficulty of writing an abstract (Roundy), present a sample abstract (Sekey), state the usefulness of the abstraction exercise (Orth), and discuss the theory of redundancy in abstracts (Lipson).

Orth (1972) reports on the value of the abstracting process for making the writer more disciplined. He first lists his observations about the abstract:

1. it is the most prominent part of the report
2. it is read by more people than any other part of the report
3. it exists for a busy administrator's or executive's convenience
4. upon the basis of it alone, action often is determined
5. it must be written so that all potential readers can understand it
6. it includes the essence of the report.

These observations, he says, show the abstract's value to the reader as a finished product. There are additional benefits, however, since writing abstracts requires special attention to several common writing devices:

- cohesive elements and phrases
- repetition of key words
- parallel grammatical construction
- pronouns to refer to key words.

By practicing writing abstracts, Orth says, the writer can improve the writing skills of "clarity, exactness, conciseness, and directness" (44).

In a brief article on abstracts, summaries, and conclusions, Sekey (1973) states that contrary to the suggestions made by some technical writing texts, the abstract of an engineering or scientific report should have a separate identity from the report's summary or conclusion. The point of the article seems to be that the parts of a report have different functions and should be written separately. This point will be discussed in Chapter Five.

Lipson (1983) focuses on how readers organize the information being presented in a report. She concludes that the repetition created by the standard report format ("abstract" followed by an "introduction" that repeats much of the same material) is helpfully redundant. This format builds context so that the reader will be able to understand the "body" of the report that follows.

Roundy (1982) discusses the problem students have in writing abstracts. The problem seems to be a significant one, since it was one that she says "no amount of outlining articles, talking about major and minor generalizations, or studying finished abstracts seemed to alleviate" (34). Her solution is a "Process Approach":

1. devise a sentence including the major topics in the table of contents. This sentence, which predicts or forecasts the order of information in the report, will function both as a descriptive abstract and as the thesis of an informative abstract.

2. summarize the main facts under each topic. Retain both the order and the weight of information in the report.

3. edit the abstract. Cut adjectives, adverbs, and transitional words. Consider sentence lists.

We have seen the first two of these suggestions before, of course, but the third contradicts a number of technical writing texts that have been reviewed above. Several texts state that in the editing process the writer should do just the opposite of Roundy's suggestion. Specifically, several texts suggest rewriting the abstract to include cohesive elements and to avoid the telegraphic style which Roundy calls "sentence lists."

JOURNAL GUIDES FOR AUTHORS

Eleven technical journals and several authors' guides for technical journals were examined for this section. The "Instructions for Contributors" page, which is usually found on the inside back cover of each journal, states the basic requirements for submissions. In general, those requirements cover only four categories: brevity, length, location, and completeness. Statements about brevity are quite vague, as the examples below indicate, and usually are confined to a brief description, such as "short," "carefully worded," or "suitable for publication." Statements about length and location are, on the other hand, usually quite specific, noting the maximum word limit allowed and the precise positioning of the abstract. Completeness, as seen in some of the examples below, means that the abstract should not simply state the results of the project or experiment, but should be a summary of the entire document:

- "The body of the manuscript should be preceded by a Summary (maximum length 200 words) which should be a summary of the entire paper, not of the conclusions alone." Numerical Methods in Engineering

- "Papers should be preceded by an informative summary of not more than 200 words." Journal of Pipelines

- "The article should be preceded by a summary of not more than 200 words describing the entire paper, not just the conclusions." International Journal of Soil Dynamics and Earthquake Engineering

- "The body of the manuscript should be preceded by a summary (maximum length 200 words) which should be a summary of the entire paper, not of the conclusions alone." Earthquake Engineering and Structural Dynamics

- "The second page of the manuscript for each regular paper should contain an abstract of 50-200 words, summarizing the nature and results of the research described. The abstract must be complete and self-contained, having no references to items appearing in the body of the manuscript." Journal of Magnetic Resonance

- "The abstract should be concise, indicate both the objectives and the results of the research, and be a complete statement in itself." International Journal of Fracture

- "A short abstract (not exceeding 100 words) should immediately precede the introduction. Abstracts should be most informative, giving a clear indication of the nature and range of the results contained in the paper." International Journal of Heat and Mass Transfer

- "A short abstract (50 to 100 words) should be included on the first page immediately preceding the introductory paragraph of the paper." Journal of Fluids Engineering

- "Provide a carefully worded abstract of from 100 to 200 words." Journal of Solid-State Circuits"

- "Each paper should be accompanied by an abstract suitable for publication with the paper." Optoelectronics

- "A short abstract should accompany the manuscript on a separate sheet." Computers and Structures

The striking thing about these requirements, as we saw in the textbook review, is a lack of consistency, especially in terminology. The first four examples use "summary" or "informative summary." The next three use "abstract" and include a brief statement about what should be included in the abstract, specifically, the "nature" or "objectives" as well as the "results" of the research. The last four use "abstract" without any clarifying statements.

Although the difference between the layman's understanding of "abstract" and "summary" may be slight since they both do basically the same thing, the difference may be significant to the journals. While a "summary," according to most dictionaries, is a condensation of the substance of a larger work, an "abstract" is a statement that summarizes the important points of that larger work. Thus, "summary" as used in the journal guides means not just the important points, such as the results or conclusions, but a "condensation" or an "abridgment" of the entire report. Noting this distinction, some journals state which direction they require writers to take, a direction consistent with the goals and expectations of that journal's audience. Journals that use the term "summary," it would seem, prefer a general statement about the research reported that will be suitable to a reader who is not a subject matter expert in that particular topic but is knowledgeable about the journal's field of study. Other journals, it seems, have a more specialized readership and therefore require an "abstract," which focuses on the results of the research without the need for providing the reader with any background.

This lack of precision about terminology is carried over to the use of other terms that are more standard in the textbooks than they are among the journals. In some journals the term "nature" is close to what the technical writing texts suggest for "purpose statement." For example, the Journal of Magnetic Resonance says that the manuscript should contain an abstract of 50-200 words, summarizing the nature and results of the research described." The International Journal of Heat and Mass

Transfer states that "abstracts should be most informative, giving a clear indication of the nature and range of the results contained in the paper." In these two examples, requirements for "nature" and "range" correspond to "purpose" and "scope" in the textbooks. In some cases, a journal may use the term "objectives" in place of "purpose statement." The International Journal of Fracture states that "the abstract should be concise, indicate both the objectives and results of the research, and be a complete statement in itself."

In addition to the "Instructions for Contributors" page, many journals publish a separate guide for writers submitting articles to the journal. In several journal guides, such as "Guidelines for SPIE--The International Society for Optical Engineering," "Information for IEEE Transactions and Journal Authors," published by the Institute of Electrical and Electronic Engineers (IEEE), "Journal of Metals Author Instructions," and "Author Instructions for Camera-Ready Special Technical Publications" of the American Society for Testing and Materials, the most frequently mentioned requirements for abstracts are "scope" and "results."

The "Manuscript Preparation" section of the "Information for IEEE Transactions and Journal Authors" states that "the abstract of 50-200 words should concisely state what was done, how it was done, principle results, and their significance." These requirements roughly correspond to what the technical writing texts call "scope" ("what was done"), "methods" ("how it was done"), "results" ("principal results"), and "conclusions" ("their significance"). "Purpose" and "recommendations," however, are not mentioned.

In the "Journal of The Minerals, Metals & Materials Society Author Instructions," as in four of the technical journals mentioned above, the abstract is called a "summary," and should describe the "topic, experimental results or scope of the paper in 3-4 sentences." "Purpose," which was recommended by eleven of the fifteen textbooks, is not specifically mentioned by any of the journal guides, although "purpose" did appear to be included in the term "nature" as noted above. "Recommendations," which was mentioned by ten of the textbooks is not mentioned by any of the journal guides as a requirement for an abstract.

It appears from this overview that there are three general abstract categories for writers who wish to publish their manuscripts in these technical journals: the "summary," which abridges the entire report; the "abstract," which focuses on results; and an "other" category, which can be either a summary or an abstract since many journals allow the writer to construct the abstract without guidance. Constructing the abstract without guidance, however, can be a difficult task since the writer is then left to search a textbook or a journal for an appropriate sample of an abstract to use as a pattern. Finding an appropriate abstract in a journal can be complicated since, as will be discussed in Chapter Three, there are at least four recognizable strategies or approaches that writers appear to use when they construct their abstracts: a narrative approach, a definition of terms, a statement of facts, and a statement of results. In any one volume of a journal, examples of all four approaches may appear.

CONCLUSION

The current state of advice about constructing abstracts that a writer may access either from textbooks, journal articles, or author's guides, displays a variety and complexity that may create more questions in the minds of many abstract writers than produce sufficient answers. Chapter Three: Materials and Methods will describe how the 48 abstracts were examined to determine what strategies practicing writers of technical and scientific documents use to construct their abstracts. Chapter Four: Results will describe the data gathered from that examination, and Chapter Five: Discussion, Conclusions and Implications will discuss the results in greater detail.

CHAPTER THREE

MATERIALS AND METHODS

The first section of this chapter, "Materials," will briefly describe how the 48 reports used in this study were selected. It will also include the first five abstracts and where they were published. This section will conclude with a description of what previous editorial review the 48 reports had undergone.

The second section, "Methods," will explain how the various categories used to analyze the 48 reports were determined. This section will include how the "Descriptive" and "Informative" categories and the "Summarizing Strategies" were determined, how the "structural" elements and the "stylistic" elements were counted, and how the tables and charts were constructed to track these categories.

THE MATERIALS

During 1990 and 1991, 48 scientific and technical reports were submitted by the Research and Development Department of a large corporation to the Corporate Office for final editing and publication approval. All the reports submitted during those two years are included in this study.

The scientists and engineers who wrote these documents perform research on topics related to the energy services industry, which includes improvements in fossil fuel and nuclear steam generating equipment, testing and maintaining that equipment, and the environmental impact of using the equipment. The authors report their findings to internal audiences in the form of a final report and to external audiences generally in the form of conference papers presented to technical societies. Those papers are then submitted for publication either in the conference proceedings or in a technical journal in the subject area of the paper's topic.

The first five abstracts are included here to provide some insight into the type of abstracts that were examined in this study. A complete set of the abstracts as well as the titles of the reports and where they were published can be found in Appendix A and B.

ABSTRACT #1
STATUS REPORT - FABRICATION AND CLOSURE DEVELOPMENT OF NUCLEAR WASTE DISPOSAL CONTAINERS FOR THE YUCCA MOUNTAIN PROJECT

In GFY89, a project was underway to determine and demonstrate a suitable method for fabricating thin-wall monolithic waste containers for service within the potential repository at Yucca Mountain [1]. A concurrent project was underway to determine and demonstrate a suitable closure process for these containers after they have been filled with high-level nuclear waste [2]. Phase 1 for both the fabrication and closure projects was a screening phase in which candidate processes were selected for further laboratory testing in Phase 2 [3]. In GFY89, Phase 2 work was underway in both cases to test the various candidate processes and select one for mock-up demonstration [4]. GFY89 Phase 2 fabrication efforts have established preliminary estimates of the cost for fabricating monolithic thin-walled containers from CDA 715 and Incoloy 825 [5]. GFY89 Phase 2 closure efforts have evaluated three potential closure processes (friction welding, plasma arc welding, and electron beam welding) and indicated the feasibility of achieving sound closures in a number of candidate materials [6]. Friction welding appears to be particularly promising in this regard [7]. More work needs to be done to complete the Phase 2 efforts of both projects [8]. Phase 3 in both cases will involve finalizing plans to implement the selected candidate fabrication and closure processes in the repository [9]. This report describes the final results of the Phase 1 efforts [10]. It also describes the preliminary results of Phase 2 efforts [11].

ABSTRACT # 2
ENVIRONMENTAL EFFECTS OF CORROSION FATIGUE

Corrosion fatigue is the leading cause of boiler tube failures in fossil fired power plants [1]. Laboratory investigations are underway to identify the root cause of this failure mode and to identify ameliorative actions to avoid failures [2]. Crack initiation, crack growth rate, and full tube verification testing has given some insight into the corrosion fatigue process, and has allowed the effects of key environmental variables to be identified [3]. Oxygen in the boiler water is seen to have the single largest effect on corrosion fatigue tube life [4]. The solution pH also has a large effect on tube life, especially in water with very low dissolved oxygen levels [5]. Chlorides have a small negative effect upon corrosion fatigue while sulfates and phosphates have little or no influence [6].

ABSTRACT # 3
METAL-EMBEDDED OPTICAL FIBER PRESSURE SENSOR

We report the results of work to demonstrate the feasibility of embedding a metal buffered optical fiber inside a thin metal diaphragm to create a pressure sensitive transducer [1]. A method was developed to embed butt-coupled optical fibers inside brass diaphragms [2]. Butt-coupled fibers with two different end spacings were successfully embedded in the diaphragms [3]. The pressure response of the diaphragms was calibrated by measuring the changes in light transmission through the butt-coupling as a function of pressure [4]. In addition to embedded fiber pressure sensors, this method may be useful for other applications [5]. The calibration results indicate the method could be used to make connections between signal processors and optical fibers embedded in composites [6].

ABSTRACT # 4
PERFORMANCE TESTING OF ULTRAFINE PITTSBURGH #8 COAL IN 12-INCH ADVANCED FLOTATION COLUMN

The criteria for selecting a suitable advanced physical coal cleaning technology are: (1) maximum removal of pyritic sulfur with optimum Btu recover, (2) high probability of commercial application, and (3) more cost-effective than flue gas desulfurization technology on a $/ton of sulfur removed basis [1]. One physical cleaning technology having the potential to meet these criteria is advanced froth flotation [2].

Babcock & Wilcox (B&W) has participated with ICF Kaiser Engineers to perform a DOE-supported project entitled "Engineering Development of Advanced Physical Fine Coal Cleaning Technologies - Froth Flotation [3]." B&W was responsible for performing process studies in two areas [4]. The first area was coal preparation equipment (hydrocyclones and rougher flotation cells) to prepare the coal for ultrafine grinding and advanced froth flotation (1) [5]. The second area, which is the subject of this paper, was the ultrafine grinding and advanced froth flotation testing [6]. Bench-scale and pilot scale (100 to 200 pounds/hour) tests were conducted at B&W's Alliance Research Center [7]. An 8-liter pilot-scale wet stirred ball mill was used to determine the operating conditions (rpm, media volume, feed solids concentration, and feed rate) and specific energy required to produce the ultrafine coal feed for advanced flotation [8]. Two-inch diameter and 12-inch diameter flotation column cells were used to develop engineering performance and scale-up data for the advanced flotation process [9]. The operating conditions and performance results of the ultrafine grinding and the advanced froth flotation testing are discussed [10].

ABSTRACT # 5
LOW-LEVEL STANDARDIZATION OF ELECTRICAL CONDUCTIVITY CELLS

Electrical conductivity monitors are used either independently or in conjunction with other hardware to estimate the concentration of ionized chemicals in water [1]. Until recently, this instrumentation was used primarily for trending; but, the need has developed for conductivity data that are accurate as well as precise [2]. Interference from air makes it difficult to standardize electrical conductivity monitors in the low ranges [3].

The traditional practice is to standardize at a conductivity that is up to 2700 times the lowest measured conductivity [4].

In the current tests, five flow-through conductivity cells exhibited a bias (deviation from theoretical) of -9% to +9% at 146.93 _S/cm, the usual standardization point for low-level conductivity measurements [5]. The bias was non-linear below 146.93 _S/cm, ranging from +3% to +21% at 0.055 _S/cm, the theoretical conductivity of pure water [6]. Two on-line monitors showed similar trends [7]. The upward logarithmic trend in bias at low conductivities may result from an increase in ion mobility at very dilute concentrations [8]. The bias for glass flow-through cells or on-line monitors can be reduced to the range of +1% to +3% at 0.055 _S/cm or to the range of -5% to +3% at 0.055 - 1.0 _S/cm by standardization in the range of the expected measurements using a Standard Sample Synthesizer (SSS) which blends the lowest ASTM standard solution with pure water in various ratios to produce low-level standards [9].

A final review of the document is done by the Corporate Patent Department to approve release of any proprietary information and by the Corporate Communications Department for editorial comments. The editorial comments made by the Communications Department are usually minimal, however, since each document has already undergone several reviews at the Division where it was written. Those reviews consist of examinations by the author's Section Manager, the Laboratory Director, the New Idea Coordinator, the Technical Papers Coordinator, and, finally, by the Research and Development Coordinator of the sponsoring Division.

THE METHODS

There are three main theoretical perspectives described by Faigley (1985) to interpret writing samples:

the individual perspective, the social perspective, and the textual perspective. Faigley lists the goals of these perspectives and discusses their usefulness in researching non-academic writing. A goal of the individual perspective is "to describe the processes that are effective and those that are ineffective so that effective strategies can be taught to ineffective writers" (235). A goal of the social perspective is to describe "social relations, tensions, or conflicts that go beyond the text as a physical object and the writer as an isolated strategist" (236). A goal of the textual perspective is to provide results which can be used "to make generalizations that are sometimes stated prescriptively as rules for style and format" (234). All of these goals apply to this dissertation and a combination of perspectives helps to provide a broader explanation of the gaps between suggestions the technical writing textbooks and journal guides make about structural and stylistic features, and the evidence of the 48 sample abstracts studied here. A combination of methods is necessary since, as related in Chapter one, it is typical of subject matter experts to be unable to describe their most intuitive tasks in any structured way. Meningitis diagnosticians couldn't do it, and the technical and scientific writers in this study gave no indication that writing abstracts was either an important task to them, or one that occupied much of their thoughts.

The method used in this dissertation, then, is a combination of the individual, social, and textual perspectives, or what Lauer and Ascher call "thick description" (287, 1988).

Determining the categories in which the data was to be placed and describing those categories will be discussed below. Selecting the data for each category was done by means of a close reading of the abstracts and the texts following Bazerman's method of examining scientific articles (167-74, 1988). Data from the textbooks is shown in Tables 2 and 3, and data from the abstracts is shown in Tables 4 and 5. The counts were verified by a colleague to ensure accuracy.

Analyzing the Textbooks--Table 2

In Table 2: Summary of Textbook Recommendations About Style, the authors and publication dates of each text are listed in the left column, and the stylistic elements are listed across the top of the Table. The stylistic elements include: "Cohesive Elements," "Conjunctions," "First Person," "Passive Voice," "Jargon," "Abbreviations," "Parallel Structure," and "Telegraphic Writing." This list was revised extensively for Tables 4 and 5, Data Analysis Charts since some of the stylistic elements suggested by the textbooks were found so infrequently in the abstracts that several elements were deleted. The changes from Table 2 to Tables 4 and 5 are as follows:

- "Eliminate Unnecessary Words" - even though mentioned by five of the texts, this category was deleted since it was not possible from the data to determine what words had been eliminated.

- "Avoid Telegraphic Writing" - although mentioned by four of the texts, this category was deleted since no evidence of telegraphic writing was found in any of the 48 abstracts.

- "Use Parallel Structure" - this category was deleted since it was the least often mentioned stylistic element in the Literature Review and since there was very little evidence of this category in the abstracts.

- "Use Subordination" - this category was deleted since it was only mentioned twice in the Literature Review and because of its infrequent occurrence in the abstracts.

- "Avoid Jargon and Abbreviations" - this category was separated into two categories for the Data Analysis Chart: "Jargon Use" and "Abbreviation Use."

- "Jargon Use OK" - this category was deleted since the categories of "Jargon Use" and "Abbreviation Use" were included above.

- "Must Stand Alone" - although mentioned by thirteen of the fifteen texts, this category was deleted since all the abstracts fit this category.

- "Passive Voice" - this category was added to the Data Analysis Chart because of the emphasis many technical writing texts place on writing in the active voice.

The stylistic categories that remained in Tables 4 and 5 after the above changes were made are:

- Use of Transitional Words
- Use of First Person
- Number of Passive Sentences
- Number of Jargon Words
- Number of Abbreviations
- Number of Words
- Number of Sentences
- Average Number of Words per Sentence

In addition to the stylistic elements, Table 2 lists the suggested abstract length mentioned by each text.

Table 3: Summary of Textbook Suggestions About Structure is constructed in the same manner, listing the structural elements across the top of the table: "Purpose," "Scope," "Methods," "Results," "Conclusions," and "Recommendations."

Tables 4 and 5 included whether the abstracts were "Descriptive" or "Informative," which summarizing strategy was used, and which of the stylistic and structural elements mentioned in Tables 2 and 3 and whether they were "Prefabricated," "Recast," or "Rewritten." Finally, each abstract's number of words, number of sentences, and average number of words per sentence was listed. The first line of the Chart was labeled "Type of Abstract," indicated either by "D" for "Descriptive" or "I" for "Informative." The second line was labeled "Summarizing Strategy," indicated by "N" for narrative strategy, "D" for definition of terms, "F" for statement of facts, or "R" for statement of results. Line three of the chart was labeled "Sentence Matching," indicating notations for one of seven possible matching categories:

- "A" - Rewritten
- "P-I" - Prefabricated primarily from the Introduction
- "P-C" - Prefabricated primarily from the Conclusion
- "P-I&C" - Prefabricated primarily from both the Introduction and the Conclusion
- "R-I" - Recast primarily from the Introduction
- "R-C" - Recast primarily from the Conclusion
- "R-I&C" - Recast primarily from both the Introduction and the Conclusion.

Next were listed the "Structural Elements": Purpose, Scope, Methods, Results, Conclusions, and Recommendations. This list was revised slightly from the original list of structural elements found in Table 3: Summary of Textbook Recommendations About Structure. The "Findings" category was deleted since "Findings" duplicates the "Results" category.

Each of the appropriate boxes was marked with a "check" if the abstract contained the structural element in that category, or by "0" if it did not. In the "Purpose" category, however, the box was marked either with the number of the sentence in which the "statement of purpose" occurred, or by "0" when no purpose statement was found.

In the reports themselves, a variety of section headings were used in addition to the traditional structural categories of Introduction, Background, Results, Discussion, Conclusions, and Recommendations found in the textbooks. Certain headings were combined, and there were many sections with specific headings (e.g., "Description of the Chemistry Monitoring System," "Diagnostic Tools," "NOX Port Modeling," and "Fuel Switching Alternatives"). A list of the heading categories along with the number of occurrences of each category in the 48 abstracts follows. Aside from the specific headings in the reports, there were 18 combinations of generic headings in all:

Introduction - 48

Background - 6

Experimental Procedures - 4

Results - 14

Procedure and Results - 1

Table 2 - SUMMARY OF TEXTBOOK RECOMMENDATIONS ABOUT STYLE

	Length	Eliminate Unnecessary Words	Avoid Telegraphic Writing	Use Subordination	Use Transitions	Use Parallel Structure	Avoid 1st Person	Avoid Jargon and Abbreviations	Jargon Use O.K.	Must Stand Alone
1. Sherman 1966	10%	✓	0	0	0	0	✓	✓	0	✓
2. Blicq 1972	125-250 words	0	0	0	0	0	0	0	✓	0
3. Andrews & Blickle 1978	6% or 150-300 words	✓	✓	✓	0	0	0	0	✓	✓
4. Stratton 1984	2%-10%	0	0	0	0	0	0	✓	0	✓
5. Mills & Walter 1986	5%	0	✓	0	0	0	0	✓	0	✓
6. Carosso 1986	1 paragraph-1page	0	0	0	0	0	0	0	0	✓
7. Brusaw, Alred, & Oliu 1987	200-300 words	✓	✓	✓	✓	✓	0	0	✓	✓
8. Emerson 1987	1 page	0	✓	0	✓	0	0	✓	0	✓
9. Houp & Pearsall 1988	5-10% or <200 words	0	0	0	0	0	✓	0	0	✓
10. Markel 1988	<200 words	0	0	0	0	0	0	0	✓	✓
11. Day 1988	<250 words	✓	0	0	0	0	0	✓	0	✓
12. Damerst & Bell 1990	10%	✓	✓	0	✓	0	0	0	✓	✓
13. Mathes & Stevenson 1991	100-250 words	0	0	0	0	0	0	0	0	0
14. Olsen & Huckin 1991	0	0	0	0	0	0	0	0	0	✓
15. Lannon 1991	0	✓	0	0	✓	0	0	✓	0	✓
TOTALS		6	5	2	4	1	2	6	5	13

Table 3 - SUMMARY OF TEXTBOOK RECOMMENDATIONS ABOUT STRUCTURE

	Purpose or Need	Scope	Methods	Results	Findings	Conclusions	Recommendation
1. Sherman 1966	0	0	0	0	0	0	0
2. Blicq 1972	✓	0	✓	0	✓	✓	0
3. Andrews & Blickle 1978	✓	✓	✓	✓	✓	✓	✓
4. Stratton 1984	0	0	0	0	0	✓	0
5. Mills & Walter 1986	✓	✓	0	0	✓	✓	✓
6. Carosso 1986	✓	✓	✓	✓	✓	✓	✓
7. Brusaw, Alred, & Oliu 1987	✓	0	✓	✓	0	✓	✓
8. Emerson 1987	✓	✓	✓	0	0	✓	✓
9. Houp & Pearsall 1988	0	0	0	0	0	✓	✓
10. Markel 1988	✓	✓	✓	✓	✓	✓	✓
11. Day 1988	✓	✓	✓	✓	0	✓	0
12. Damerst & Bell 1990	0	0	0	0	0	✓	✓
13. Mathes & Stevenson 1991	✓	0	✓	✓	✓	✓	✓
14. Olsen & Huckin 1991	✓	0	✓	✓	✓	✓	0
15. Lannon 1991	✓	0	0	0	✓	✓	✓
TOTALS	11	6	9	7	8	14	10

Table 4 - DATA ANALYSIS CHART: ABSTRACTS 1-24

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24
Type of Abstract*	I	I	U	D	I	I	D	I	D	U	D	D	U	I	I	I	D	U	I	D	D	I	I	D
Summarizing Strategy**	N	F	R	F	F	N	N	N	D	R	D	F	D	N	N	D	F	F	F	F	F	F	R	R
Sentence Matching***	RI	RI	RC	RI	PC	A	RI&C	A	RI	A	A	PI	RI	P&IC	A	RI	PI	A	A	A	A	P&IC	RI&C	A
Structural Elements																								
Purpose-Sentence #	9	0	1	10	0	0	0	2	5	1	7	8	0	1	3	0	3	5	4	6	3	0	1	1
Scope	✓	0	✓	✓	0	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
Methods	✓	0	✓	✓	✓	✓	✓	✓	0	0	0	0	✓	0	✓	✓	0	0	0	✓	✓	✓	✓	✓
Results	✓	✓	✓	0	✓	✓	✓	✓	0	0	0	0	✓	✓	✓	✓	0	✓	✓	0	0	✓	✓	0
Conclusions	✓	0	✓	0	✓	✓	0	✓	0	✓	0	0	✓	✓	✓	✓	0	0	✓	0	0	✓	✓	0
Recommendations	0	0	✓	0	✓	0	0	0	0	✓	0	0	✓	0	0	✓	0	0	0	0	0	0	0	0
Stylistic Elements																								
Use of Transitional Words	0	0	0	2	1	2	0	1	0	0	1	1	0	1	0	0	0	1	0	0	0	1	1	0
Use of First Person	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0
# Passive Sentences	1	1	3	4	3	2	1	7	1	5	4	2	3	3	8	3	2	1	7	0	2	9	4	3
# Jargon Words	7	4	3	3	5	8	6	14	3	6	4	17	5	6	2	8	7	1	5	3	4	10	16	5
# Abbreviations	2	1	0	5	3	3	5	9	7	4	1	7	4	1	7	5	2	2	6	5	1	3	9	2
# of Words	223	129	110	229	220	343	92	303	143	181	188	201	143	211	272	166	132	111	222	175	156	343	416	90
# of Sentences	11	6	6	10	9	16	5	14	5	7	10	9	8	9	13	6	4	5	11	7	6	17	12	4
Average Words/Sentence	20	22	18	23	24	19	18	22	29	26	19	22	18	23	21	28	33	22	20	25	26	20	34	25

*** Type of Abstract**
D = Descriptive
I = Informative
U = Undecided

**** Summarizing Strategy**
N = Narrative
D = Definition of Terms
F = Statement of Facts
R = Statement of Results

***** Sentence Matching**
RI&C = Recast from Introduction & Conclusion
PI = Prefabricated from Introduction
PC = Prefabricated from Conclusion
PI&C = Prefabricated from Introduction & Conclusion
RI = Recast from Introduction
RC = Recast from Conclusion
A = Rewritten

Table 5- DATA ANALYSIS CHART: ABSTRACTS 25-48

	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40	41	42	43	44	45	46	47	48
Type of Abstract*	D	D	I	U	U	D	D	U	U	I	I	I	D	I	I	D	I	U	D	I	D	U	I	U
Summarizing Strategy**	F	F	F	F	F	F	F	R	R	R	R	F	R	F	F	D	F	N	F	F	R	F	F	N
Sentence Matching***	A	A	A	A	A	A	A	RI&C	RI&C	A	A	RI	A	PI	RI&C	RI&C	RI&C	A	A	RC	A	PI	A	A
Structural Elements																								
Purpose-Sentence #	11	8	0	3	5	5	5	1	1	1	2	3	1	9	0	2	6	1	2	5	1	10	5	0
Scope	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
Methods	✓	✓	✓	✓	✓	0	0	✓	✓	✓	✓	✓	0	✓	✓	✓	✓	✓	0	0	0	✓	✓	✓
Results	0	0	✓	✓	✓	0	0	✓	✓	✓	✓	✓	0	✓	✓	0	✓	✓	0	✓	0	0	✓	✓
Conclusions	0	0	✓	✓	✓	0	0	✓	✓	✓	✓	✓	0	✓	0	0	✓	0	0	✓	0	✓	✓	0
Recommendations	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Stylistic Elements																								
Use of Transitional Words	0	1	0	0	0	0	0	1	0	0	1	0	0	0	1	0	3	0	0	0	0	1	1	1
Use of First Person	0	0	0	0	0	1	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0
# Passive Sentences	6	2	8	3	5	1	0	4	0	2	3	7	5	3	10	5	7	6	2	2	4	4	4	4
# Jargon Words	6	4	11	10	3	2	3	1	16	3	7	8	8	4	11	8	5	3	1	4	16	3	4	7
# Abbreviations	2	0	8	0	5	0	2	1	0	1	9	6	0	1	14	1	2	0	1	2	2	3	4	7
# of Words	165	176	360	178	153	92	136	123	105	199	228	186	117	173	320	131	307	153	36	206	174	207	177	193
# of Sentences	11	8	13	10	7	5	5	5	4	8	10	10	6	9	20	7	15	8	2	12	8	10	8	9
Average Words/Sentence	15	22	28	18	22	18	27	25	26	25	23	19	20	19	16	19	20	19	18	17	22	21	22	21

*** Type of Abstract**
D = Descriptive
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**** Summarizing Strategy**
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A = Rewritten

Results and Discussion - 4

Discussion - 7

Analysis - 1

Conclusion and Discussion - 1

Conclusions and Recommendations - 5

Results and Discussion - 3

Summary - 7

Conclusions - 30

Summary and Conclusions - 5

Recommendations - 4

Future Activities - 1

Future Work - 1

From this list it is possible to conclude that all of the reports began with a section labeled Introduction (100%), Chapter Four discusses further implications of these headings.

A broader description follows of how the choice was made for the "descriptive" and the "informative" categories as well as an explanation of the summarizing strategies and the "sentence matching" methods.

Descriptive or Informative

The technical writing textbooks offer several guidelines to describe the difference between descriptive and informative abstracts. In general, the "descriptive" abstract, as Houp and Pearsall say, "discusses the report, not the subject" (214). For example, after reading a "descriptive" abstract the reader would know that new findings on the report's topic are presented, but the reader would not know what those findings are. An "informative" abstract, on the other hand, is a summary of "the key information" in the complete report (209). So the decision to call an abstract "descriptive" or "informative" was based on whether it contained results or findings. If the abstract presented results of some type, then it was called "informative." If not, it was called "descriptive." Not all of the reports themselves contained a results or a findings section. Generally, as shown above, the reports began with a section called Introduction or Background, followed by several sections with a variety of specific headings based on the type of equipment used or on some special feature of the experiment (e.g., "Numeric Modeling," "Pre-Combustion Methods," "Pilot Scale Study," "Equal Weight Quadrature"). After these sections the reports used a variety of methods to state results and to sum up the report in some fashion (e.g., "Conclusions and Recommendations," "Summary and Conclusions," "Results and Discussion"). Although most of the reports contained some type of concluding section (47 reports), only 22 reports contained a section with results or findings. If the sections in the reports labeled "Discussion" are included as part of the results or findings category, the number increases to 35 reports. This information will be discussed further in Chapter Four.

The distinction between "descriptive" and "informative" abstracts blurred when the statement of results or conclusions was not clear cut. For example, Abstract #2, "Environmental Effects of Corrosion Fatigue," contains the following statement of results: "Chlorides have a small negative effect upon corrosion fatigue, while sulfates and phosphates have little or no influence." This abstract was labeled "informative" since it contained at least a general description of the research. In Abstract #4, "Performance Testing of Ultrafine Pittsburgh #8 Coal in 12-Inch Advanced Flotation Column," a statement that describes the method of the research could also be seen as "results": "An 8-liter pilot-scale wet stirred ball mill was used to determine the operating conditions (rpm, media volume, feed solids concentration, and feed rate) and specific energy required to produce the ultrafine coal feed for advanced flotation." This abstract was judged to be "descriptive" since this sentence is a statement about the methods of the experiment, and not clearly about the results of the experiment. In cases where it could not be determined if an abstract was descriptive or informative, the abstract was termed "undecided." A discussion of the implications of these categorizing problems follows in Chapter Four.

Summarizing Strategies

Summarizing strategies are suggested by several of the technical writing textbooks since the ability to summarize is crucial to the abstracting process. Andrews and Blickle (182) and Mills and Walter (67) recommend writing a prose form of the table of contents.

Damerst and Bell suggest stating in one sentence the central idea of the whole message, then arranging supporting ideas in their order of importance (132). Sherman recommends going over the report one section at a time and making notes (194). Similarly, Lannon suggests a five step process:

1. read the entire original
2. reread and underline
3. edit the underlined data
4. rewrite in your own words
5. edit your own version.

Although no clear evidence of any of these suggestions could be traced, the abstracts did seem to fall into several rhetorical arrangements. In general, all the abstracts began in one of four ways: by describing the steps of the experiment or how it proceeded, by stating a definition of the parts or the equipment involved in the experiment, by stating some fact that is well known to those familiar with the report's field of study, or simply by reporting the results of the experiment or study. These rhetorical arrangements can be described as follows:

1. narrative focus - the abstract primarily focuses on the sequence of events of the research project as the central organizing point; e.g., "In FY 89, a project was underway to determine and demonstrate a suitable method for fabricating thin-wall monolithic waste containers for service within the potential repository at Yucca Mountain. A concurrent project was underway to determine and demonstrate a suitable closure process for these containers after they have been filled with high level nuclear waste. Phase 1 for both the fabrication and closure projects was a screening phase in which candidate processes were selected for further laboratory testing in Phase 2 (Abstract #1).

2. definition of terms - the abstract describes the features or parts of the research project; e.g., "E-Sox is a coal-fired boiler retrofit SO2 emission control technology which involves modification of an existing electrostatic precipitator (ESP) to include a lime slurry atomization system. SO2 emission reduction and particulate collection are performed in the modified ESP" (Abstract # 13).

3. statement of facts - the abstract begins with a factual statement and then shows how the experiment described in the report adds to the body of knowledge about that fact; e.g., "Corrosion fatigue is the leading cause of boiler tube failures in fossil fired power plants. Laboratory investigations are underway to identify the root cause of this failure mode and to identify ameliorative actions to avoid failures" (Abstract #2).

4. statement of results - the abstract focuses primarily on stating the results of the experiment or study;

e.g., "We report the results of work to demonstrate the feasibility of embedding a metal buffered optical fiber inside a thin metal diaphragm to create a pressure sensitive transducer" (Abstract #3); "The results of destructive examinations of uncooled and air-cooled specimens removed from an experimental coal-fired atmospheric limestone fluidized bed after exposures of about 500, 1000 and 2000 hours are reported" (Abstract #10).

These strategies provided a useful method to determine the predominant choice of summarizing strategy among the practicing technical writers in this group.

Matching Method

A useful way to further analyze the abstracts was to compare the sentences in the abstract with the sentences in the body of the report to determine if there were any "matches." The degree of matching would indicate how independently the abstract was written from the report. Each sentence of the abstract was read, followed by a close reading of the accompanying report so that the abstract, according to its degree of matching, could be placed into one of three matching categories:

- Prefabricated - a greater than 75% correlation of the words and syntax in the abstract with the words and syntax somewhere in the report's body (in other words, a near word-for-word match),

- Recast - a 50% correlation of the words and syntax in the abstract with the words and syntax somewhere in the report's body (in other words, only occasional matches),

- Rewritten - a less than 25% correlation of the words and syntax in the abstract with the words and syntax in the report's body (in other words, almost no matches).

The "Prefabricated" and the "Recast" categories were then further divided into three sub-categories: "primarily derived from the Introduction," "primarily derived from the conclusion," and "primarily derived from the introduction and the conclusion." The importance of this classification will be discussed in Chapter Five, Conclusions and Implications. Chapter Four will analyze the data from the Tables described in this chapter.

CHAPTER FOUR

RESULTS

This chapter first presents a brief statement of the results shown in Tables 4 And 5 in Chapter Three, then discusses the data according to "Type of Abstract," "Summarizing Strategy," "Sentence Match," "Structural Elements," "Stylistic Elements," and "Length and Number of Sentences." The conclusions and implications from these results will be discussed in Chapter Five.

In general, writers of these 48 abstracts preferred to begin writing their abstracts by stating facts. Although many technical writing texts suggest starting off with a purpose statement, only ten of the 48 abstracts in this study contained a purpose statement in the first sentence. Only five of the abstracts contained all of the structural elements (scope, methods, results, conclusions, and recommendations) that were suggested by the technical writing texts. The most often included structural element was "Scope," which occurred in 46 of the abstracts. The most often omitted element was "Recommendations," which occurred in only five of the abstracts.

Some of the concerns found in the technical writing texts did not show up in the data. For example, although the abstracts in this study were often concise, there was no evidence of "telegraphic style," or the exclusion of articles, pronouns, or conjunctions. Use of the first person was also rare, occurring in only four of the abstracts.

A similarly small number of occurrences was found when technical terms, such as terms for specific technical processes, names for special materials, or terms for technical equipment, were used. If these terms are classified as jargon, jargon use occurred a total of 314 times in 9,094 words, or 6.5 times per abstract. Abbreviations, which were most often in the form of the second reference of technical terms, occurred 165 times (3.25 times per abstract). Writing in the passive voice, however, was found in abundance in these abstracts and will be discussed below under "Stylistic Elements."

When the number of words per abstract was counted, abstracts in this study kept well below the upper limit of 250 words suggested by several textbooks, and within the general guidelines of 100 to 200 words suggested by many of the journals. Only eight of the abstracts were longer than 250 words. The average number of words per abstract was 189; the average number of words per sentence was 22; and the average number of sentences per abstract was 8.75.

Another major concern of the technical writing texts was that abstracts must be written to "stand alone." All the abstracts in this study succeeded in standing alone since none contained any references to the full report. A more detailed description of the results follows.

DESCRIPTIVE VERSUS INFORMATIVE

Of the 48 abstracts, 20 were determined to be "Informative" (41.6%), 17 were determined to be "Descriptive" (35.4%), and 11 were "undecided" (22.9%). The "Informative" abstracts and the "Descriptive" abstracts were spread throughout the samples without any apparent correlation with the summarizing strategy, with the stylistic and structural elements, or with the contents of the reports themselves. It appears that the Informative-Descriptive distinction is not a meaningful one for the abstracts written by the scientists and engineers in this group or, for that matter, for the journals for which they write. Although there is clearly a distinction between the abstract types as they are described in the texts (e.g., the difference between the road map by itself and the road map with significant sights along the way), the distinction is not mentioned in any of the journal guides even though it is widely discussed by the 15 technical writing texts. As noted earlier, the reason for this disjunction follows from the didactic nature of textbooks, which tends to discriminate among abstract types, while the utility of industry journals does not.

THE FOUR SUMMARIZING STRATEGIES

The four "Strategies" in this category were "Narrative," "Definition of Terms," "Statement of Facts," and "Statement of Results." There were 25 abstracts in the "Statement of Facts" category, the largest of the four categories at 52%. The next largest category was "Statement of Results," with a total of 10 abstracts for 20.8%. Next was the "Narrative" category, with 8 abstracts for 16.6%, and finally, the "Definition of Terms" category with 5 for 10.4%.

Although evaluating each abstract for a summarizing method turned out to be somewhat subjective, these four categories proved to be instructive in seeing an overall pattern preferred by the 48 writers in this group. If the "Statement of Facts" and the "Statement of Results" categories are considered as one strategy since they display much of the same basic organizational techniques, over 70% of the 48 abstracts showed a preference for a linear, step by step description of the report being abstracted. In general, then, it appears that writers of these 48 abstracts preferred a sequential statement of facts as a strategy for constructing their abstracts. Chapter Five discusses this pattern in more detail.

SENTENCE MATCHING

Perhaps the greatest surprise in the analysis of the data came in this category. From the writers' comments reported in Chapter One, if any part of the writing task (completing the long process of analyzing the data, writing the report, checking the documentation, and developing the graphical materials) would suffer from a writer's lack of focus and attention, it would be writing the abstract. Simply repeating parts of the introduction or the conclusion to create a "prefabricated" abstract would be the easiest route to completing the report writing task. This turned out not to be the case in most of these abstracts.

Of the 48 abstracts studied, just over half (25) were "Rewritten," that is, they were in the "weak correlation" category where there was almost no word for word match between the sentences of the abstract and the sentences of the report's body.

The "Recast" category, which was between having a high correlation of sentence matches and a low correlation, contained sixteen abstracts: seven recast from the Introduction, two from the conclusion, and seven recast from the Introduction and the Conclusion.

Only seven abstracts were considered to be "Prefabricated," four from the Introduction of the report, one from the Conclusion of the report, and two from the Introduction and the Conclusion of the report. Almost all of the abstract writers in this study (41 including the "Recast" category) were able to write the abstract without "Prefabricating" it.

This finding lends significant insight into the process of writing abstracts in the non-academic world. Roundy, Sherman, and others have noted the difficulty of teaching students how to write abstracts in the classroom, yet it appears from the writers' comments in Chapter 1 that real world technical writers find it far less difficult to construct abstracts than do academically based writers since real world writers have a clear sense of purpose and professional needs. The implications of this finding are further discussed in Chapter Five.

STRUCTURAL ELEMENTS

Data on the number of occurrences and percentages of the six "Structural Elements" (purpose statement, scope, methods, results, conclusions, and recommendations) are presented below. From these numbers, it appears that the technical and scientific writers of the 48 abstracts preferred to state the scope of their work as their first priority, followed closely in importance by a statement of purpose. Forty-six abstracts contained a statement of scope (95.8%), 36 had a purpose statement (79.2%), 33 contained a statement of methods (68.7%), 30 contained a statement of results (62.5%), 26 contained a conclusions statement (54.1%), and only 5 contained a statement about recommendations (10.4%). Table 6: Summary of Structural Elements Found in the 48 Abstracts gives the totals and percentages of elements found compared to how many times these elements were suggested by the textbooks.

Purpose Statement

A purpose statement was recommended by eleven of the fifteen textbooks and occurred in almost 80% of the abstracts. Of the six structural elements recommended by the textbooks, purpose statement was second in frequency only to Scope. These results show that a purpose statement is not only a stalwart of academic writing suggestions, but is an essential component of successful real-world writing since it appears with such regularity in these 48 abstracts.

Since so many of the abstracts included a purpose statement, the four summarizing strategies were examined to determine if the location of the purpose statement presented some differentiating data. In the "Narrative" category there were eight abstracts. Three contained no

Table 6 - SUMMARY OF STRUCTURAL ELEMENTS FOUND IN THE 48 ABSTRACTS

Structural Elements	Number of Occurences in 48 Abstracts	Percentage	Number of Textbooks Suggesting Use	Percentage
Purpose	38	79.2%	11	73.3%
Scope	46	95.8%	6	40.0%
Methods	33	68.7%	9	60.0%
Results	30	62.5%	7	46.6%
Conclusions	26	54.1%	14	93.3%
Recommendations	5	10.4%	10	66.6%

purpose statement at all, four contained a purpose statement within the first three sentences, and one did not show a purpose statement until after the eighth sentence. In this small category, there was an unusually large number of abstracts without a purpose statement. Since this category centered on the report's sequence of events in contrast to the other 40 abstracts, the primary focus appears to have remained on the sequence, and secondarily on the purpose of the research.

In the "Definition of Terms" category, also a small category, two of the five abstracts did not contain a purpose statement. One contained the purpose statement in the second sentence, one contained a purpose statement in the fifth sentence, and one contained a purpose statement in the seventh sentence. As in the "Narrative" category above, this category centered primarily on defining the features or parts of the study rather than on the purpose. These two categories, which make up only 27% of the total number of abstracts, contained half of the abstracts without purpose statements.

The next two categories showed quite different data from the previous two. Nine of the ten abstracts in the "Statement of Results" category contained a purpose statement in the first sentence. The other abstract in this category contained the purpose statement in the second sentence. Writers in this group seemed to closely relate results and purpose when summarizing the reports of their experiments. This linkage makes sense since writers in a category noted for its delineation of results would by necessity have a clear understanding of the purpose of the project in order to evaluate that project's results.

In the final and largest of the categories, "Statement of Facts," 20 of the 25 abstracts contained a purpose statement. No purpose statement occurred in the first sentence, one occurred in the second sentence, and four occurred in the third sentence. The other fifteen abstracts in this category did not show a purpose statement until after the fourth sentence, with half of those not occurring until the eighth sentence or later. Writers in this category seemed to be able to significantly delay the purpose statement. It appears that the majority of scientific and technical writers in this group felt that beginning the abstract with factual statements takes precedence over the necessity of stating the report's purpose. Even so, stating facts did not deter most of these writers from eventually including a purpose statement.

Methods

A statement of Methods was recommended by nine of the technical writing texts and occurred in 33 abstracts, or 68.7%. Methods was not a distinct heading in any of the full reports, although four reports did contain a section called "Experimental Procedures," and one report contained a section called "Procedure and Results." In the full reports, the experimental procedure was often discussed under a specific heading (see examples in Chapter Three) which described the particular apparatus used or the procedure followed.

Results

A statement of results was recommended by seven of the texts and occurred in 30 abstracts (62.5%). Twenty-four of the full reports (50%) contained a section called either "Results" (19 reports), "Results and Discussion" (3 reports), "Discussion and Results" (1 report), or "Procedure and Results" (1 report). In addition, seven reports contained a section simply called "Discussion." If "Discussion" is included in the "Results" count, the number of reports which contained a section in some way describing results increases to 31 (64.5%). Thus, in this category, the abstracts and the reports were similar.

Conclusions

Conclusions occurred in 26 abstracts, or 54.1%. This number was unexpectedly low, since fourteen of the fifteen textbooks stated that an abstract should contain information about the report's conclusion and 46 (95.8%) of the reports themselves contained some type of conclusions section (e.g., "Conclusions," "Conclusions and Discussion," "Conclusions and Recommendations," "Summary," and "Summary and Conclusion"). A possible explanation for this finding, as noted in the "Summarizing Strategies" section above, is that over 70% of these abstracts are in either the "Statement of Facts" category or in the "Statement of Results" category, and a mere statement of the facts may imply a conclusion to readers who are familiar with the report's topic.

Recommendations

Recommendations occurred in only five abstracts, or 10.4%. This structural element was the least important to the abstract writers in this group even though ten of the textbooks suggested that an abstract include a statement of recommendations. The low number of recommendations in the abstracts mirrors the low number of recommendations in the reports themselves. Only nine of the reports had a recommendations section (18.7%).

As with the unexpectedly low number of conclusions above, the limited number of recommendations among these abstracts, besides reflecting the structure of the reports, may be due to several reasons: the self-evident nature of factual abstracts which make up a large proportion of the abstracts studied here may preclude stating a recommendation, or no recommendation may be required and no action need be taken. In many cases, readers who are knowledgeable of the report's topic can infer their own recommendations from the factual evidence presented in the abstract. Finally, as a practical matter, space can be saved by not stating any recommendations.

Scope

Only six of the textbooks recommended including Scope, yet a statement of Scope occurred in 46 abstracts, or 95.8%. It is important to note here that as used in these abstracts, Scope is not text-based but rather experiment-based. That is, the writers of these abstracts describe the scope of the experiment, not the scope of the report. Thus, these abstracts are brief descriptions of the actual experiment. (e.g., abstract # 12, "The paper addresses the application aspects of this Ct parameter considering the effects on life prediction assuming plane stress versus plane strain and steady-state creep versus primary plus steady-state creep for various cracked geometries," abstract # 37, "Information is given on the microbend fiber optic sensor approach used to measure diaphram deflection and requirements for microbend sensor thermal compensation," and abstract # 40, "A parametric analysis was conducted to determine the variation of the first and second natural periods with parameters such as pile length, base width, deck payload, water depth, and pile area.") This difference in scope of project versus scope of report is significant since it again points out a non-academic writing practice that is different from some textbook suggestions. Of the six technical writing texts discussed in Chapter 2 which suggest that scope be included in the abstract, three define scope as a list of the contents of the report (Brusaw, et al, Emerson, and Markel), and three define scope as a statement of the extent of the experiment (Andrews and Blickle, Mills and Walter, and Day). This latter definition, scope as a statement of the extent of the experiment, seems to be the one used by the technical and scientific writers in this study.

The discovery here that scope is almost universally used among these abstracts is one of the most significant in this dissertation. Practicing technical and scientific writers in this group chose to include scope regardless of any of the other structural elements required by the journals or by the needs of their readers. It is difficult to know why more textbooks did not suggest including scope in the abstract. Perhaps it is because scope appears to be an unnecessary "overview" that takes up valuable space that should be saved for results or conclusions. But here is where the textbooks miss the point. The "overview" is the abstract, and scope is the writer's most efficient tool for providing the reader with an overview of the experiment or project about which the report is written. Thus, the most useful recommendation this dissertation has to make about writing abstracts comes from this finding. This information may provide technical writing practitioners with useful data to improve how they structure their abstracts and give textbook authors insight into the structural elements used by one group of practicing technical and scientific writers in industry. Further implications of this finding will be discussed in Chapter Five.

STYLISTIC ELEMENTS

The Stylistic Elements Category, unlike the Structural Elements Category, showed a close correlation to the textbook suggestions. In general, the writers in this group avoided telegraphic style, jargon, abbreviations, and the first person when writing their abstracts. First person usage occurred in only 4 abstracts, or 8.3%. Jargon occurred 314 times, or 3.4% of a total number of 9,049 words in the 48 abstracts. Abbreviations were used 165 times, or 1.8% of the total number of words. Cohesive elements such as "however," "therefore," and "but," appeared in 18 abstracts or 37.5%.

The use of passive voice, however, was the striking exception to this general adherence to the textbook suggestions for style. There were 192 passive sentences out of a total of 420 sentences (45.7%). Of the passive verbs used in these sentences, 178 (92.7%) were "agentless passives." Although it is a common stricture in technical writing textbooks as well as in composition texts that writers avoid writing passive sentences, the relatively frequent use of passives in these abstracts indicates that writers make little attempt to avoid passives. In fact, "truncated" or "agentless" passives are useful for abstracting information since they eliminate the "actor" or "agent" in a sentence. The use of passive voice is discussed further in Chapter Five.

CHAPTER FIVE

DISCUSSION, CONCLUSIONS AND IMPLICATIONS

In The Interpretation of Cultures, Clifford Geertz identifies "thick-description ethnography" as "the aim to draw large conclusions from small, but very densely textured facts; to support broad assertions about the role of culture in the construction of collective life by engaging them exactly with complex specifics" (28, 1973). In many ways, this dissertation is a "thick description" of one aspect of one task performed by a well defined group of people engaging in a highly specialized and, to a great extent, individualized activity. The "complex specifics" have been presented in the previous four chapters; what remains is formulating the "broad assertions."

Stating those assertions, however, can be problematical. As Geertz says, "we begin with our own interpretations of what our informants are up to, or think they are up to, and then systematize those" interpretations (p. 15). In the case of these technical and scientific abstracts, systematizing the interpretations is challenging since access to the "tacit knowledge" of these writers is difficult to get overtly. "Tacit knowledge" is "based on repeated personal experiences, as well as on socially shared categorizations" which mark specific discourse genres (Van Dijk, 160). As demonstrated by the comments of these writers in Chapter One, they have derived the "tacit knowledge" of how to write abstracts through repeated experience, and they use that knowledge, as Odell, et. al., say, "without having to formulate it consciously each time they write" (223, 1983). Thus, interpretation from several perspectives becomes a necessary part of drawing "large conclusions" from such a small slice of the writing life of these scientists and engineers. Creating a systematic interpretation of largely intuitive events is, as Geertz says, like creating a "fiction," in that it is "something made," "something fashioned," not that it is either "false, unfactual, or merely 'as if' thought experiments" (p. 15). The interpretation created in this chapter is based on the weight of the details of the previous four chapters as well as a "thick description" of the writers' remarks recorded in Chapter 1.

RE-DEFINING THE ABSTRACT

We know that an abstract is a different kind of text from the text of a full report for several obvious reasons, namely, the condensed nature of the abstract (what Swales calls its "distilled quality"), the position of the abstract as a separate piece at the head of an article or report, and the difference in font or type style in which the abstract is often printed (in italics or in some other font that contrasts with the full text). All of these signal the reader as to the unusual, non-traditional nature of the abstract and identify the abstract as a genre which has a special purpose (Kieras, 1982). That special purpose, according to Van Dijk is to "convey to the reader what the intended semantic macrostructure of the text will be, so that the reader need not construct this macrostructure from the sentences of the text, a bottom-up process that is much more difficult" (p. 161).

To construct that macrostructure, readers know that the title of a technical or scientific report is the most dense information, next dense is the abstract, and least dense is the full text. Repeated exposure gives readers the "tacit knowledge" of this document pattern (Odell, Goswami, and Herrington, 1983). Because of the abstract's uniqueness and the "tacit knowledge" of the reader, abstract writers are able to maximize the rhetorical assumptions they make about reader expectation. Some of the traditional parts of a scientific or technical document, therefore, can be excluded. Contrary to what is implied by many of the textbooks (Mathes and Stevenson, Mills and Walter, Lannon, Day), the abstracts studied here are not reduced, mirror images of the full text with all of its attendant parts, nor are they the structural equivalent of the report in miniature (in fact, only five of the 48 abstracts in this study contained all of the structural elements suggested by the textbooks).

The features that make up abstracts, according to Swales, "are recognized by the expert members of the parent discourse community, and thereby constitute the rationale for the genre. This rationale shapes the schematic structure of the discourse and influences and constrains choice of content and style. . . . Exemplars of a genre exhibit various patterns of similarity in terms of structure, style, content and intended audience" (p. 58). The structure, style, and content of these technical and scientific abstracts, are easily recognizable by the reader because of the "conventional" nature of their construction. As van Dijk says, "from a production point of view, most forms of discourse that result from professional or institutional processing exhibit fixed categorical properties, which allow routine production of such texts" (p. 160).

In this sense, abstract writers are similar to journalists who write news stories. Journalists "operate with conventional, shared categories that define a well-formed news report" (Van Dijk, 1990, p. 160). Like journalists, scientists and engineers who write abstracts of their reports share a similar set of conventions. The difference between journalists and technical writers, however, is that journalists can be taught in journalism classes to use news article conventions to write well-formed articles, while writers of technical and scientific documents absorb abstract writing conventions on-the-job. Similarly, Barabas's study (1990) of 44 progress reports from a research and development organization found that "the vast majority of good writers (63 percent) and poor writers (91 percent) said they learned expectations regarding progress reports by sheer experience--by 'trial and error'" (191). The notion that technical and scientific writers must learn abstract writing on-the-job helps to explain the responses of the abstract writers in Chapter One. When questioned about how they composed their abstracts they were unable to define any strategies. For these writers, constructing abstracts has become "conventional" and, like the case of the experts who diagnosed meningitis, what is "conventional" becomes difficult to explain. As we have seen, the most immediately striking discovery from the previous chapters is that the structure of abstracts of scientific and technical articles printed in journals and conference proceedings differs significantly from the textbook suggestions for structuring abstracts.

Reader expectation of the genre of abstracts supports the abstract writer's ability to condense information and to rely on the reader's expectation that the abstract will have a reduced number of connectives, a reduced number of "agents" in sentences, and reduced overall cohesiveness. These characteristics establish the conventions of the scientific or technical abstract format. According to van Dijk, "the cultural nature of genre schemata guarantees that the relevant rules are shared by group members who know the genre, even when there are personal or situationally variable strategies for the application of the rules" (p. 159). What we have seen in the data presented in this dissertation is consistent with Van Dijk's observation. The principle abstract writing convention for the group of 48 scientific and technical writers studied here can be stated as follows: when abstracting a technical report, the primary structural strategy is to describe the scope of the project or experiment and the primary stylistic strategy is to use frequent, agentless passive constructions.

DESCRIPTIVE VS. INFORMATIVE

One of the most obvious conclusions of this study is that the distinction made by the textbooks between an informative and a descriptive abstract is unclear. Eleven of the 48 abstracts were not clearly descriptive or informative. Many of the other abstracts were not classifiable by the standards suggested in the textbooks. As an alternative to the descriptive-informative differentiation, data from this dissertation suggests that a more useful convention for classifying abstracts may be one that reflects the four categories outlined in Chapter Three: the Narrative focus, the Definition of Terms, the Statement of Facts, or the Statement of Results. These four categories appear to describe more realistically how practicing technical writers organize their abstracts. The kind of abstract to be written should, of course, depend on the type of study that was done and the length limits of the journal or proceeding in which the report is to be published. But technical writers need not be confined to two types of prescriptive forms of abstracts. They should be guided by what will fit the specific rhetorical circumstances for which they are writing. Thus, one of the ways data from this dissertation can be used to benefit the field of technical writing is to show that textbooks should revise their descriptions of informative and descriptive abstracts to focus on one of the four summarizing strategies suggested above: Narrative, Definition of Terms, Statement of Facts, or Statement of Results.

PASSIVE VS. ACTIVE

Textbooks on writing have traditionally cautioned the writer against using the passive voice because it was thought that passive constructions make it more difficult for the reader to comprehend a sentence. Even recent texts continue to describe how passives are believed to cause comprehension problems (Flower, 1985, Munter, 1992). Flower states that "readers must mentally transform such structures into active ones as they are reading in order to comprehend them" (1985, 198). Research has shown, however, that comprehending passive sentences can be no more difficult than comprehending active sentences (see sample sentences below). Clark and Clark (1977, 106) cite several studies which conclude that "under the right circumstances, passives can actually be easier than actives" to understand. If the reader understands the object of a sentence to be "given," the passive takes less time to comprehend than the active. The "circumstances" Clark and Clark describe involve the idea of what is "given" information for the reader and what is "new" information. "Given" information, as described in Chapter Two, is often provided to the reader of a technical report by a combination of the information present in the report's title and the reader's ability to access stored knowledge about that information.

Although the active form of a sentence is more often encountered and used than is the passive form, "the passive form is more apt to be encountered where the attention is directed on the 'natural' object of the situation" (Tannenbaum and Williams, 1968, 250). This is essentially what the writer of an abstract is attempting to do. The writer assumes that the reader is interested in what was done during the experiment or study, not in who did it. This focus on the experiment is especially true in the case of the passive sentences in these 48 abstracts. Thus, most of the passives here involve what Flower calls the difference between a "personal" and an "impersonal" style. The "impersonal" style with its emphasis on factual events is just what the writer is attempting to do in abstracting data from a full report. The "agent" of the action can often be irrelevant to the purpose of the abstract. The 48 abstracts in this study show frequent, representative examples of eliminating the agent of the action:

- "A method is described using an EMAT (Electromagnetic Acoustic Transducer) Lamb wave method to inspect a large pipe by removing only a narrow strip of marine growth for access" (Abstract #5).

- "Illinois No. 6 mine-run coal, washed coal, and coal cleaning waste by-products from a Murdock, Illinois, mine were tested in a 30-foot-tall, small-scale (1 million-Btu/hr), circulating fluidized-bed combustor (CFBC) located at the Babcock & Wilcox (B&W) Alliance (Ohio) Research Center" (Abstract #8).
- "An overview of B&W's research and development (R&D) facilities and two coal-fired commercial units is presented in this paper" (Abstract #19).
- "The computed displacements and stresses on the quadrupole magnet components are presented" (Abstract # 25).
- "It was also determined that fatigue cracking has always been responsible for both shaft initiation and propagation mechanisms and cracking can occur independent of shaft material" (Abstract #27).

In these sentences, writers are able to use the passive form to focus on what went on during the project or experiment, not on the agent of the events in the experiment. Of the 192 passive sentences in the 48 abstracts, 178 were agentless passives. Agents of verbs such as conducted, used, discussed, observed, loaded, demonstrated, reported, and removed can be deleted. The reader understands that the agents of these verbs represent "given" information not necessary to understanding the highly condensed information in the abstract. This seems to be why more than 45% of the sentences of the abstracts in this study are passive.

Since abstracting information directs attention to the natural object of the situation, another conclusion of this dissertation is that authors of technical writing textbooks drop the suggestions they make for reduced use of passives when writing abstracts and instead suggest that passive constructions may be used as an additional method for condensing information. The "elaborate derivational machinery," as Levinson (1983, 41) calls it, of being able to plan for either an active construction or a passive construction provides the writer with another vehicle for fulfilling the reader's needs.

REDUCED NEED FOR STRUCTURAL ELEMENTS

The textbooks and journal guides in this study agree on three essential points about abstracts: that abstracts must be written to stand alone, that abstracts are read as a substitute for reading the full report, and that conciseness is of paramount importance. An abstract, clearly, requires certain structural elements to perform these functions. But other elements, as this study shows, are not necessary for successful abstracts. When writers of the 48 reports in this study condensed their reports, it appears that they needed foremost to convey the scope of the project. Over 95% of the abstracts in this group contained a statement of scope.

A statement of recommendations, on the other hand, was found in only 10%.

As outlined above and as noted by many of the technical writing textbooks reviewed in Chapter Two, readers traditionally use abstracts to determine quickly and independently which reports most closely fit their needs or interests by identifying the subject of the study being described. The subject is initially identified by the title, which can be quite lengthy and descriptive in many scientific and technical articles (see the list of abstract titles in the Appendix). The title evokes the relevant schema and begins the process of constructing the macrostructure the reader needs to comprehend the report.

After reading a clearly descriptive title, the reader may need an additional differentiating tool to determine if the report would add measurably to the reader's knowledge of the topic. Stating the scope, which outlines the steps taken during the project, gives the reader that tool.

The use of scope as the predominant structural element in these abstracts can also be explained to a large extent by the third requirement of abstracts stated above: that conciseness is of paramount importance. If the scope has been well written, there may be little else required in the abstract since the reader can find other information about the project in the appropriate sections of the full text of the report. Important results and conclusions can easily be located by the reader under these headings. All but one of the reports contained some type of clearly labeled concluding section (e.g., "Conclusions," "Conclusions and Recommendations," "Summary and Conclusions"), and thirty-five of the reports contained a section entitled either "Results," "Discussion," or "Results and Discussion."

Being able to locate the results or the conclusions, however, does not always provide the reader with information about the equipment used, the components employed, or the duration of the experiment, all of which obviously have bearing on the results. Only five of the 48 full reports contained a clearly marked section in which the reader could expect to find the scope ("Experimental Procedure" - 4 reports, and "Procedure and Results" - 1 report). In many cases, then, the reader must search the full report for the components of the experiment which are described under a variety of headings. These headings approximate "Scope" in one fashion or another, however not in a condensed or easily located form. Thus, the abstract becomes an appropriate place for a brief description of the scope of the project. In supplying readers with sufficient information for selecting reports to read, then, successful abstract writers often include scope rather than results in the abstract.

WRITERS OF ABSTRACTS

In an engineering company such as the one for which the reports used in this study were written, there are several constraints facing scientists and engineers who write in this discourse community. The two primary constraints which have an impact on the written products they produce are cost and time. Each project that a research and development division undertakes is usually done for one of two reasons: to refine an existing product because of customer complaints or observed malfunction; or to develop a new product to answer a need in the marketplace. Researchers who work on projects of the first type, to refine an existing product, can be under great pressure to come up with cost-effective and timely solutions that satisfy the customer, maintain the company's reputation, and save the company money from product liability action or from the cost of replacing faulty equipment. In the case of this particular engineering company, since it manufactures fossil fuel and nuclear power generating equipment as well as offshore marine equipment, the costs of replacing faulty equipment can be quite high. Researchers who work on projects of the second type, to bring a new product to market, are under no less pressure since any number of competing R & D departments in other companies may be attempting to fill that market need as well.

In addition to the pressure of minimizing the cost related to equipment, there is also pressure to minimize the cost in salary, benefits, and overhead for these highly paid research scientists and engineers. Thus the amount of time researchers are allowed to develop a solution or bring a product to market is usually limited. In the case of a faulty product that needs to be re-engineered, an acceptable level of efficiency must be found as soon as possible so that the customer can generate the expected revenue from that product. In the case of developing a new product, if the company can successfully meet the market's needs, it can generate years of company growth through spin-off products and future refinements. In either case, the research staff must be able to provide management with the answers it demands and deliver those answers in the shortest time possible.

Because speed in developing and refining products is so crucial to these researchers and because management demands speed, productively using time to focus on the product becomes a paramount strategic practice in the working life of these scientists and engineers. When asked about their abstracting strategies, two themes emerged in their responses which reflect this fundamental approach to working in a modern company: a focus on product and a sense of urgency. Two of these writers in particular demonstrate these themes. One is a member of the Paper Review Committee of the American Society of Mechanical Engineers and an expert in refining power generating equipment to reduce the output of nitrous oxide into the atmosphere, the other is an expert in metal corrosion. When asked to outline the strategy he uses to construct his abstracts, the first writer replied, "I describe the problem, then the installation of the equipment, then describe the scope of what we are trying to do. I emphasize results and benefits." After a pause he said, "I've written a lot of papers, but never looked at any references for writing abstracts. I guess I just evolved into it. I use common sense, but carefully adhere to any journal guidelines." After another pause he continued, "I wrote an abstract, if I remember correctly, about a twelve million dollar savings for the plant and great reduction in the output of nitrous oxide. That set the stage for the paper." Three elements of this response are typical of the responses of the 48 writers in this group: the practical, step by step approach which makes a transition from a general statement to a specific example; the tendency to abbreviate speculation about the process; and the focus on the value-added nature of the actual product about which the report is written. This focus of practicing technical writers on product is another distinguishing element of the difference between the world of industry and the world of the classroom. Since one of the roles of the classroom is to provide students with insight into theories and processes that later may be applied successfully to some occupational effort, stating the distinction here between the classroom focus and the industrial focus helps to remind us that for many of those outside of academia, the memory of studying academic processes fades, like Wordsworth's "glimpses" of immortality, as the corporate employee becomes galvanized into a professional posture which, to a large extent, is one of survival. When the first writer above was asked to talk more about the process of abstracting, he said, "the abstract must answer the question, 'Why would I want to read the article?' When I'm casually glancing at journal articles, I look for a statement of results in the abstract. As a reader, why should I take the time to read it? I look for the 'so what,' not a description of a new product introduction or a cheap form of advertising. The abstract is the place to put the punch." What is revealing about this statement is not only the revelation of a reading habit that combines time-saving and problem-solving strategies, but a strong sense of urgency. As the second writer said, "I look for an abstract with solutions to a problem I am currently working on, in a similar environment, and with a similar experimental method. I guess the more you read abstracts, the better you get at writing them." These writers show a clear preference for focusing on practical, expedient matters. In fact, one of the key indicators management searches for in a promotable corporate employee is a well-founded sense of urgency, a sense that allows management to feel secure that the individual responsible for completing the task will do so with all due diligence. Although this sense of urgency can be called by other terms, such as professional responsibility, a clear understanding of speed is one of the intangible results of having absorbed the corporate culture and is one attribute that separates those who are promotable from those who are not. Because this sense of urgency is so pervasive in corporate employees who have survived the shrinkage of many large American companies in general, and this engineering company in particular, not much time is allocated for speculation about process, especially the process of writing. The brevity of these writers' speculative comments again points out the reason research on technical writing outside the university is difficult. The goal of such research in the eyes of a non-academic practitioners is either unclear, or impractical, or specious. Philosophical speculation about writing does not seem to be an appropriate or interesting effort for these writers; however, discussing the solution to a particular problem is a topic of continuing interest. These writers are highly articulate scientists and engineers and are quite capable of describing what goes on when "a" meets "b" under condition "x." When asked to describe a project, they will first opt to take the questioner to the lab for a firsthand look. When the opportunity for a firsthand look does not exist, their second choice of explanatory methods is to sketch on paper some type of design to explain the product or process on which they are working. This common practice of using a quick sketch to provide visually a macrostructure for the listener is generally reflected in the second theme in these responses, the focus on product. The product provides value to the company in terms of a salable commodity and brings job security for at least a short while to the producer.

Process is not an issue beyond the individual writer who may have a few moments from time to time to wax philosophical, hands behind head, while the boss is on a business trip; then the telephone rings, and the boss is calling between planes to check on the progress of the project. So even the reflective moments are generally spent pondering something tangible about the product, not something egocentric like how one goes about constructing an abstract. So ingrained in these writers is the focus on product that when pressed to comment on their abstract writing strategies, these writers detoured quickly into the applied versus the theoretical.

Most of the comments from these writers, as shown in Chapter One, were along the lines of the writer who said, "there is no time to work on a separate abstract." Common responses were: "summarize and hit the high points"; "condense, go for meaning first"; "explain the paper in two minutes or six sentences"; "the abstract is constructed from knowledge of the product"; and "try to sell it in the abstract." Although such comments may be sufficient general descriptions that other practitioners can comprehend due to the shared tacit knowledge of a discourse community, it tells the writing researcher little about the process these writers employ. Questions which attempt to probe the writer's depth of tacit knowledge reveal little introspection about the process of writing. The writer shows difficulty in articulating the process and thus, as in the case of the first writer's remarks, defaults to a practical example.

The impact which these constraints, especially time, have on the written products of the scientists and engineers in this study can be seen in the structural elements which make up their abstracts--they produce a quick "sketch" of the project. As the results of this research show, these writers use scope as the most efficient method to sketch the outline of a project and to give the reader the context necessary to understand details found in the report.

CONCLUSION

This dissertation has attempted to describe the stylistic and structural elements these 48 scientists and engineers used to construct their abstracts. As a result of this research, we can state at least three things about the writers and their abstracts. First, we know that the textbook information about how to write abstracts is well intentioned, even helpful (especially in suggestions about style), but largely disregarded by writers in this group. The textbooks offer appropriate generic advice for students who write a variety of abstracts for university-based papers, but once the context of the non-university setting becomes primary and immediate, as shown by the comments of the writers at this corporate research and development division, contextual knowledge replaces textbook knowledge. Although we cannot say from this research if other industrial settings provide similar contextual knowledge, it may be the case that each industry provides its own form of contextual knowledge.

The second thing we know from this research is that these abstract writers show a clear preference for using scope as the primary structural element in constructing their abstracts. Third, we know that these writers frequently use passive constructions as a major stylistic element in their abstracts. These findings diverge from the textbook suggestions for constructing abstracts in two ways: scope is not a strongly recommended structural element in the textbooks and passive voice is generally discredited as a stylistic element. The ability of these technical and scientific writers to successfully structure abstracts seems to be derived principally from closeness to the writing project and from experience. This dissertation has attempted to describe how that experience manifests itself in the structural and stylistic elements of these 48 non-academic technical abstracts.

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APPENDIX A

LIST OF JOURNAL REQUIREMENTS FOR ABSTRACTS

1. "The body of the manuscript should be preceded by a Summary (maximum length 200 words) which should be a summary of the entire paper, not of the conclusions alone." Numerical Methods in Engineering

2. "Papers should be preceded by an informative summary of not more than 200 words." Journal of Pipelines

3. "The article should be preceded by a summary of not more than 200 words describing the entire paper, not just the conclusions." International Journal of Soil Dynamics and Earthquake Engineering and Structural Dynamics

4. "The body of the manuscript should be preceded by a summary (maximum length 200 words) which should be a summary of the entire paper, not of the conclusions alone." Earthquake Engineering and Structural Dynamics

5. "The second page of the manuscript for each regular paper should contain an abstract of 50-200 words, summarizing the nature and results of the research described. The abstract must be complete and self-contained, having no references to items appearing in the body of the manuscript." Journal of Magnetic Resonance

6. "The abstract should be concise, indicate both the objectives and the results of the research, and be a complete statement in itself." International Journal of Fracture

7. "A short abstract (not exceeding 100 words) should immediately precede the introduction. Abstracts should be most informative, giving a clear indication of the nature and range of the results contained in the paper." International Journal of Heat and Mass Transfer

8. "A short abstract (50 to 100 words) should be included on the first page immediately preceding the introductory paragraph of the paper." Journal of Fluids Engineering

9. "Provide a carefully worded abstract of from 100 to 200 words." Journal of Solid-State Circuits

10. "Each paper should be accompanied by an abstract suitable for publication with the paper." Optoelectronics

11. "A short abstract should accompany the manuscript on a separate sheet." Computers and Structures

APPENDIX B

LIST OF SPONSORING ORGANIZATIONS, MEETING TITLES, AND PUBLICATION TITLES FOR TECHNICAL REPORTS USED IN THIS STUDY

Report # 1
STATUS REPORT - FABRICATION AND CLOSURE DEVELOPMENT OF NUCLEAR WASTE DISPOSAL CONTAINERS FOR THE YUCCA MOUNTAIN PROJECT

Sponsoring Organization: American Nuclear Society (ANS)
Meeting Title: Focus '91 - Nuclear Waste Packaging
Publication Title: "Conference Proceedings"

Report # 2
ENVIRONMENTAL EFFECTS OF CORROSION FATIGUE

Sponsoring Organization: Electric Power Research Institute (EPRI)
Meeting Title: International Conference on Boiler-Tube Failures
Publication Title: "Conference Proceedings"

Report # 3
METAL-EMBEDDED OPTICAL FIBER PRESSURE SENSOR

Sponsoring Organization: Society of Photo-optical Instrument Engineers (SPIE)
Meeting Title: OE Fibers '90
Publication Title: "Conference Proceedings"

Report # 4
PERFORMANCE TESTING OF ULTRAFINE PITTSBURGH #8 COAL IN 12-INCH ADVANCED FLOTATION COLUMN

Sponsoring Organization: American Flame Research Committee (AFRC) and Japanese Flame Research Committee (JFRC))
Meeting Title: International Conference on Environmental Control of Combustion Processes
Publication Title: "Conference Proceedings"

Report # 5
LOW-LEVEL STANDARDIZATION OF ELECTRICAL CONDUCTIVITY CELLS

Sponsoring Organization: Electric Power Research Institute (EPRI)
Meeting Title: Measuring Waterborne Trace Substances
Publication Title: "Conference Proceedings"

Report # 6
FUEL CHARACTERIZATION OF COAL/SHREDDER TIRE BLENDS

Sponsoring Organization: Electric Power Research Institute (EPRI)
Meeting Title: Waste Tires as a Utility Fuel Publication Title: "Conference Proceedings"

Report # 7
STRAIN RATE SENSITIVITY OF ALLOY 718 STRESS CORROSION CRACKING

Sponsoring Organization: French Society of Nuclear Engineers (SFEN)
Meeting Title: Fontevraud II
Publication Title: "Conference Proceedings"

Report # 8
CIRCULATING FLUIDIZED-BED COMBUSTION TESTING OF ILLINOIS COAL

Sponsoring Organization: Coal and Slurry Technology Association (CSTA)
Meeting Title: 15th International Conference on Coal and Slurry Technology
Publication Title: "Conference Proceedings"

Report # 9
SNRB CATALYTIC BAGHOUSE LABORATORY PILOT TESTING

Sponsoring Organization: American Institute of Chemical Engineers (AICE)
Meeting Title: AICE Summer National Meeting
Publication Title: "Conference Proceedings"

Report # 10
EXAMINATION OF MATERIALS EXPOSED IN A COAL-FIRED FLUIDIZED BED AIR HEATER EXCHANGER

Sponsoring Organization: National Association of Corrosion Engineers (NACE)
Meeting Title: Corrosion '91
Publication Title: "Conference Proceedings"

Report # 11
SHAPE MELTING TECHNOLOGY

Sponsoring Organization: Management Roundtable, Inc.
Meeting Title: 3rd International Conference on Desktop

Manufacturing
Publication Title: "Conference Proceedings"

Report # 12
USING Ct TO PREDICT COMPONENT LIFE

Sponsoring Organization: American Society for Testing and Materials (ASTM) Committee E-24 on Fracture Testing
Meeting Title: 22nd National Symposium on Fracture Mechanics
Publication Title: Using Ct to Predict Component Life

Report # 13
E-SOx 5-MWe PILOT DEMONSTRATION RESULTS

Sponsoring Organization: Electric Power Research Institute (EPRI) and Environmental Protection Agency (EPA) Meeting Title: 1990 SO2 Control Symposium
Publication Title: Symposium Proceedings

Report # 14
EXPERIENCE WITH WATER SAMPLING AND CHEMISTRY MONITORING EQUIPMENT

Sponsoring Organization: National Association of Corrosion Engineers (NACE)
Meeting Title: Corrosion '91
Publication Title: Proceedings of Corrosion '91

Report # 15
LIMESTONE AND ITS ROLE IN NOx EMISSIONS IN THE AFBC PROCESS

Sponsoring Organization: The University of Pittsburgh
Meeting Title: Pittsburgh Coal Conference
Publication Title: "Conference Proceedings"

Report # 16
SIMULTANEOUS SOx/NOx/PARTICULATE REMOVAL IN A HIGH TEMPERATURE BAGHOUSE

Sponsoring Organization: American Flame Research Committee (AFRC) and Japanese Flame Research Committee (JFRC)
Meeting Title: International Conference on Environmental Control of Combustion Processes
Publication Title: "Conference Proceedings"

Report # 17
ON-LINE IMAGING AND EMISSIVITY MEASUREMENTS TO DETERMINE FURNACE CLEANLINESS

Sponsoring Organization: International Joint Power Generation Conference (IJPGC) and American Society of Mechanical Engineers (ASME)
Meeting Title: 1991 Conference
Publication Title: "Conference Proceedings"

Report # 18
NUMERICAL MODELS AS COMBUSTION SYSTEM DESIGN TOOLS

Sponsoring Organization: Pittsburgh Coal Conference
Meeting Title: 8th Annual Conference
Publication Title: "Conference Proceedings"

Report # 19
PERFORMANCE COMPARISON OF BABCOCK & WILCOX COMMERCIAL CIRCULATING FLUIDIZED BED BOILERS

Sponsoring Organization: National Natural Science Foundation of China
Meeting Title: 2nd International Symposium of Coal Combustion
Publication Title: "Conference Proceedings"

Report # 20
REBURNING SCALE-UP METHODOLOGY FOR NOx CONTROL FROM CYCLONE BOILERS

Sponsoring Organization: American Flame Research Committee (AFRC) and American Society of Mechanical Engineers (ASME)
Meeting Title: Joint Power Generation Conference and American Flame Research Conference
Publication Title: "Conference Proceedings"

Report # 21
TECHNICAL CONSIDERATIONS IN USING LOW-SULFUR-FUEL SWITCHING AS A CLEAN-AIR-ACT COMPLIANCE OPTION

Sponsoring Organization: American Flame Research Committee (AFRC) and American Society of Mechanical Engineers (ASME)
Meeting Title: Joint Power Generation Conference and American Flame Research Conference
Publication Title: "Conference Proceedings"

Report # 22
SELECTION OF A WELD JOINT CONFIGURATION FOR PLASMA ARC WELDING OF HP-9NI-4Co-0.30C ASRM CASING STEEL

Sponsoring Organization: American Institute of Aeronautics and Astronautics (AIAA) and Society of Automotive Engineers (SAE) and American Society of Electrical Engineers (ASEE) and ASMR Joint Conference
Meeting Title: Joint Propulsion Conference (27th Annual)
Publication Title: "Conference Proceedings"

Report # 23
PILOT-SCALE DEMONSTRATION OF THE LIDS SYSTEM FOR LOW-COST BOILER POLLUTION CONTROL

Sponsoring Organization: National Natural Science Foundation of China
Meeting Title: 2nd International Symposium of Coal Combustion
Publication Title: "Conference Proceedings"

Report # 24
FIELD TEST RESULTS ON FIBER OPTIC PRESSURE TRANSMITTER SYSTEM

Sponsoring Organization: Society of Photo-Optical Instrumentation Engineers (SPIE)
Meeting Title: OE/Fibers '91
Publication Title: "Conference Proceedings"

Report # 25
THE IMPACT OF PRESS DESIGN ON SKIN-YOKE/COLLAR PRESTRESS IN SSC COLLIDER QUADRUPOLE MAGNETS

Sponsoring Organization: The University of Alabama, Huntsville
Meeting Title: Cryogenic Engineering Conference
Publication Title: "Conference Proceedings"

Report # 26
FIELD TEST PROGRAM TO CHARACTERIZE EMISSIONS AND PERFORMANCE OF WOOD-FIRED BOILERS

Sponsoring Organization: Technical Association of the Pulp and Paper Industry (TAPPI)
Meeting Title: 1991 TAPPI Engineering Conference
Publication Title: "Conference Proceedings"

Report # 27
SUMMARY OF FAILED REACTOR COOLANT PUMP ROTATING ASSEMBLY EXPERIENCE AT CRYSTAL RIVER UNIT 3

Sponsoring Organization: Electric Power Research Institute (EPRI)
Meeting Title: Fourth Annual Workshop on Main Coolant Pumps
Publication Title: Workshop Proceedings

Report # 28
EFFECT OF REFRACTORY EMITTANCE IN INDUSTRIAL FURNACES

Sponsoring Organization: American Society of Mechanical Engineers (ASME)
Meeting Title: 1991 National Heat Transfer Conference
Publication Title: "Conference Proceedings"

Report # 29
INSPECTION OF PIPE COVERED WITH MARINE GROWTH

Sponsoring Organization: None
Meeting Title: None
Publication Title: Materials Evaluation (Special Issue), Spring 1992

Report # 30
COAL - RETROFITTING AND REPOWERING FOR FUTURE USE

Sponsoring Organization: World Coal Institute
Meeting Title: First World Coal Institute Conference: "Coal In the Environment"
Publication Title: Coal--Retrofitting and Repowering for Future Use

Report # 31
SITE LOGISTICS AND THE IMPACT ON PFBC DESIGN

Sponsoring Organization: Power Generation
Meeting Title: Power Generation Conference
Publication Title: "Conference Proceedings"

Report # 32
APPLICATION OF STATISTICAL PROCESS CONTROL TECHNIQUES FOR INSTRUMENT EVALUATION

Sponsoring Organization: American Society for Quality Control (ASQC)
Meeting Title: 19th Annual Eastern Energy Quality

Assurance Conference
Publication Title: Workshop Papers

Report # 33
THE SELECTION OF DISCRETE ORDINATE QUADRATURE SETS FOR ANISOTROPIC SCATTERING

Sponsoring Organization: American Society of Mechanical Engineers (ASME)
Meeting Title: 1991 National Heat Transfer Conference
Publication Title: American Society of Mechanical Engineers Transactions

Report # 34
CERAMIC COMPOSITES AS CLADDING FOR WATER REACTOR FUEL ELEMENTS

Sponsoring Organization: American Nuclear Society (ANS)
Meeting Title: International Topical Meeting on Light Water Reactor Performance
Publication Title: "Conference Proceedings"

Report # 35
CYCLONE FURNACE FOR VITRIFICATION OF CONTAMINATED SOIL AND WASTES

Sponsoring Organization: University of California, Irvine
Meeting Title: 1991 Incineration Conference
Publication Title: "Conference Proceedings"

Report # 36
USE OF EMATS FOR INSPECTION OF ADVANCED SOLID ROCKET MOTOR CASINGS

Sponsoring Organization: Joint Army-Navy-NASA-Air Force (JANNAF)
Meeting Title: 1991 Nondestructive Evaluation Subcommittee Meeting
Publication Title: "Use of EMATs for Inspection of Advanced Solid Rocket Motor Casings"

Report # 37
ABSOLUTE FIBER OPTIC PRESSURE TRANSDUCER FOR AIRCRAFT AIR DATA MEASUREMENT

Sponsoring Organization: Institute of Electrical and Electronics Engineers (IEEE)
Meeting Title: National Aerospace Electronics Conference Fiber Optics Session
Publication Title: "Conference Proceedings"

Report # 38
CORROSION EFFECTS OF HIGH DEPOSIT LOADINGS DURING NUCLEAR SYSTEM GENERATOR CHEMICAL CLEANING

Sponsoring Organization: Babcock and Wilcox Nuclear Services Co.
Meeting Title: 1991 Nuclear Chemistry Technology Update
Publication Title: "Conference Proceedings"

Report # 39
COAL DEVOLATILIZATION AND CHAR OXIDATION UNDER SIMULATED PRESSURIZED FLUIDIZED-BED COMBUSTION (PFBC) CONDITIONS

Sponsoring Organization: American Society of Mechanical Engineers (ASME)
Meeting Title: The 11th International Conference on Fluidized-Bed Combustion
Publication Title: "Conference Proceedings"

Report # 40
PARAMETRIC STUDY AND DYNAMIC ANALYSIS OF COMPLIANT PILED TOWERS

Sponsoring Organization: Offshore Technology
Meeting Title: 1991 Offshore Technology Conference
Publication Title: "Conference Proceedings"

Report # 41
NOx EMISSION STUDIES IN FLUIDIZED-BED COMBUSTION

Sponsoring Organization: American Society of Mechanical Engineers (ASME)
Meeting Title: The 11th International Conference on Fluidized-Bed Combustion
Publication Title: "Conference Proceedings"

Report # 42
FOULING AND CLEANING OF A STAGGERED, FINNED TUBE BUNDLE UNDER COAL-FIRED CONDITIONS

Sponsoring Organization: American Society of Mechanical Engineers (ASME)
Meeting Title: 1991 Heat Transfer Conference, Session on Fouling and Enhancement Interaction
Publication Title: "Conference Proceedings"

Report # 43
NONDESTRUCTIVE EVALUATION OF CERAMIC HEAT EXCHANGERS

Sponsoring Organization: Society for Experimental Mechanics (SEM)
Meeting Title: 1990 Society for Experimental Mechanics Spring Conference on Experimental Mechanics
Publication Title: "Conference Proceedings"

Report # 44
PROGRESS REPORT ON AN INVESTIGATION OF FEEDWATER FLOW MEASUREMENTS AT NUCLEAR POWER PLANTS

Sponsoring Organization: Babcock and Wilcox Nuclear Services Co./SPIS
Meeting Title: 1991 Chemistry Technology Update
Publication Title: "Conference Proceedings"

Report # 45
ADVANCED NDE TECHNIQUES FOR FOSSIL-FIRED BOILERS

Sponsoring Organization: Electric Power Research Institute (EPRI)
Meeting Title: 3rd Conference on Fossil Plant Inspections
Publication Title: "Conference Proceedings"

Report # 46
ACOUSTIC EMISSION MONITORING OF HIGH ENERGY PIPING

Sponsoring Organization: Electric Power Research Institute (EPRI)
Meeting Title: 3rd Conference on Fossil Plant Inspections
Publication Title: "Conference Proceedings"

Report # 47
ASSESSMENT OF AUTOGENOUS TYPE 410S STAINLESS STEEL WELDS IN REPLACEMENT STEAM GENERATOR TUBE SUPPORT STRUCTURE

Sponsoring Organization: The Metallurgical Society (TMS) and American Nuclear Society (ANS) and National Association of Corrosion Engineers (NACE)
Meeting Title: 5th International Symposium on Degradation of Materials in Nuclear Power Systems - Water Reactors
Publication Title: "Conference Proceedings"

Report # 48
ACCELERATED IGA/SCC TESTING OF ALLOY 600 IN CONTAMINATED WR ENVIRONMENTS

Sponsoring Organization: American Nuclear Society (ANS)
Meeting Title: Fifth International Symposium on Environmental Degradation of Materials in Nuclear Power System
Publication Title: Symposium Volume

APPENDIX C

SAMPLE ABSTRACTS

ABSTRACT # 1
STATUS REPORT - FABRICATION AND CLOSURE DEVELOPMENT OF NUCLEAR WASTE DISPOSAL CONTAINERS FOR THE YUCCA MOUNTAIN PROJECT

In GFY89, a project was underway to determine and demonstrate a suitable method for fabricating thin-wall monolithic waste containers for service within the potential repository at Yucca Mountain [1]. A concurrent project was underway to determine and demonstrate a suitable closure process for these containers after they have been filled with high-level nuclear waste [2]. Phase 1 for both the fabrication and closure projects was a screening phase in which candidate processes were selected for further laboratory testing in Phase 2 [3]. In GFY89, Phase 2 work was underway in both cases to test the various candidate processes and select one for mock-up demonstration [4]. GFY89 Phase 2 fabrication efforts have established preliminary estimates of the cost for fabricating monolithic thin-walled containers from CDA 715 and Incoloy 825 [5]. GFY89 Phase 2 closure efforts have evaluated three potential closure processes (friction welding, plasma arc welding, and electron beam welding) and indicated the feasibility of achieving sound closures in a number of candidate materials [6]. Friction welding appears to be particularly promising in this regard [7]. More work needs to be done to complete the Phase 2 efforts of both projects [8]. Phase 3 in both cases will involve finalizing plans to implement the selected candidate fabrication and closure processes in the repository [9]. This report describes the final results of the Phase 1 efforts [10]. It also describes the preliminary results of Phase 2 efforts [11].

ABSTRACT # 2
ENVIRONMENTAL EFFECTS OF CORROSION FATIGUE

Corrosion fatigue is the leading cause of boiler tube failures in fossil fired power plants [1]. Laboratory investigations are underway to identify the root cause of this failure mode and to identify ameliorative actions to avoid failures [2]. Crack initiation, crack growth rate, and full tube verification testing has given some insight into the corrosion fatigue process, and has allowed the effects of key environmental variables to be identified [3]. Oxygen in the boiler water is seen to have the single largest effect on corrosion fatigue tube life [4]. The solution pH also has a large effect on tube life, especially in water with very low dissolved oxygen levels [5]. Chlorides have a small negative effect upon corrosion fatigue while sulfates and phosphates have little or no influence [6].

ABSTRACT # 3
METAL-EMBEDDED OPTICAL FIBER PRESSURE SENSOR

We report the results of work to demonstrate the feasibility of embedding a metal buffered optical fiber inside a thin metal diaphragm to create a pressure sensitive transducer [1]. A method was developed to embed butt-coupled optical fibers inside brass diaphragms [2]. Butt-coupled fibers with two different end spacings were successfully embedded in the diaphragms [3]. The pressure response of the diaphragms was calibrated by measuring the changes in light transmission through the butt-coupling as a function of pressure [4]. In addition to embedded fiber pressure sensors, this method may be useful for other applications [5]. The calibration results indicate the method could be used to make connections between signal processors and optical fibers embedded in composites [6].

ABSTRACT # 4
PERFORMANCE TESTING OF ULTRAFINE PITTSBURGH #8 COAL IN 12-INCH ADVANCED FLOTATION COLUMN

The criteria for selecting a suitable advanced physical coal cleaning technology are: (1) maximum removal of pyritic sulfur with optimum Btu recover, (2) high probability of commercial application, and (3) more cost-effective than flue gas desulfurization technology on a $/ton of sulfur removed basis [1]. One physical cleaning technology having the potential to meet these criteria is advanced froth flotation [2].

Babcock & Wilcox (B&W) has participated with ICF Kaiser Engineers to perform a DOE-supported project entitled "Engineering Development of Advanced Physical Fine Coal Cleaning Technologies - Froth Flotation [3]." B&W was responsible for performing process studies in two areas [4]. The first area was coal preparation equipment (hydrocyclones and rougher flotation cells) to prepare the coal for ultrafine grinding and advanced froth flotation (1) [5]. The second area, which is the subject of this paper, was the ultrafine grinding and advanced froth flotation testing [6]. Bench-scale and pilot scale (100 to 200 pounds/hour) tests were conducted at B&W's Alliance Research Center [7]. An 8-liter pilot-scale wet stirred ball mill was used to determine the operating conditions (rpm, media volume, feed solids concentration, and feed rate) and specific energy required to produce the ultrafine coal feed for advanced flotation [8]. Two-inch diameter and 12-inch diameter flotation column cells were used to develop engineering performance and scale-up data for the advanced flotation process [9]. The operating conditions and performance results of the ultrafine grinding and the advanced froth flotation testing are discussed [10].

ABSTRACT # 5
LOW-LEVEL STANDARDIZATION OF ELECTRICAL CONDUCTIVITY CELLS

Electrical conductivity monitors are used either independently or in conjunction with other hardware to estimate the concentration of ionized chemicals in water [1]. Until recently, this instrumentation was used primarily for trending; but, the need has developed for conductivity data that are accurate as well as precise [2]. Interference from air makes it difficult to standardize electrical conductivity monitors in the low ranges [3]. The traditional practice is to standardize at a conductivity that is up to 2700 times the lowest measured conductivity [4].

In the current tests, five flow-through conductivity cells exhibited a bias (deviation from theoretical) of -9% to +9% at 146.93 _S/cm, the usual standardization point for low-level conductivity measurements [5]. The bias was non-linear below 146.93 _S/cm, ranging from +3% to +21% at 0.055 _S/cm, the theoretical conductivity of pure water [6]. Two on-line monitors showed similar trends [7]. The upward logarithmic trend in bias at low conductivities may result from an increase in ion mobility at very dilute concentrations [8]. The bias for glass flow-through cells or on-line monitors can be reduced to the range of +1% to +3% at 0.055 _S/cm or to the range of -5% to +3% at 0.055 - 1.0 _S/cm by standardization in the range of the expected measurements using a Standard Sample Synthesizer (SSS) which blends the lowest ASTM standard solution with pure water in various ratios to produce low-level standards [9].

ABSTRACT # 6
FUEL CHARACTERIZATION OF COAL/SHREDDER TIRE BLENDS

Blends of an eastern bituminous coal and three samples of shredded car and truck tires (tire-derived fuel, or TDF) were characterized as potential fuels for a cyclone-fired utility boiler [1]. Individual chemical and physical analyses were conducted on one coal and the three tire samples [2]. The coal was typical of many eastern U.S.

bituminous coals [3]. The tires were shredded passenger car and truck tires[4].

Compared to coal, the rubber was higher in volatile content (65% versus 34%) and slightly higher heating content (13183 versus 12148 Btu/lb) [5]. The rubber samples were fairly low in sulfur content (1.3%) [6]. Unlike the coal, the rubber contained significant quantities of zinc (5 - 33% as ZnO) [7]. Ash fusion temperatures of the rubber samples were within the normal ranges of those for coal [8]. The ash viscosities of the coal/TDF blends were within the acceptable range for firing in a cyclone furnace [9].

Based on samples examined in this project, shredded tires, when mixed with coal in proportions not exceeding 20% rubber by weight, would make an acceptable fuel for cyclone furnace combustion in terms of combustion and fouling and slagging [10]. Pilot or full-scale combustion tests would verify these findings and permit determining the optimum coal/TDF blend, which may be less than or greater than 20% TDF [11].

The major concerns with TDF are potential feeding problems due to large pieces of tires and the fate of the zinc contained in the rubber [12]. Some of the tire pieces were up to 6 inches long and may plug the feeder [13]. A portion of the zinc may be expected to volatilize in the cyclone furnace and condense on fly ash particles in the cooler regions of the convection pass [14]. If this occurs to a significant degree, the fly ash may possibly have high zinc leachability [15]. If the majority of the zinc enters the cyclone furnace slag, the zinc would be largely nonleachable due to the glassy nature of cyclone furnace slag [16].

ABSTRACT # 7

STRAIN RATE SENSITIVITY OF ALLOY 718 STRESS CORROSION CRACKING

Stress corrosion cracking (SCC) tests were conducted in 360 degree C pressurized-water-reactor (PWR) primary water using Alloy 718 heat-treated to produce precipitate-free grain boundaries [1]. Fatigue precracked, 12.5-mm-thick compact fracture specimens were loaded at displacement rates from 2.5 x 10-8 to 2.5 x 10-10 m/sec [2]. At the fastest displacement rate no SCC is observed [3]. At the slowest displacement rate, SCC is observed but difficulties in in situ crack length measurement arise due to the slow test speed [4]. At intermediate rates, SCC occurs and crack growth rate is determined as a function of stress intensity factor [5].

ABSTRACT # 8
CIRCULATING FLUIDIZED-BED COMBUSTION TESTING OF ILLINOIS COAL

Illinois No. 6 mine-run coal, washed coal, and coal-cleaning waste by-products from a Murdock, Illinois, mine were tested in a 30-foot-tall, small-scale (1 million Btu/hr), circulating, fluidized-bed combustor (CFBC) located at the Babcock & Wilcox (B&W) Alliance (Ohio) Research Center [1]. The goal of the project was to promote the use of Illinois coal by demonstrating that the three fuels could be combusted efficiently and in an environmentally acceptable manner [2]. The ability to burn mine-run coal could justify eliminating the coal-cleaning step for new CFBC units [3]. A positive demonstration with the cleaning-waste by-product would reduce the cost for fuel for all users of Illinois washed coal by reducing waste disposal costs [4]. In addition, the existing stockpiles of coal wastes could be removed [5]. The project was co-funded by the Illinois Center for Research on Sulfur in Coal (SRSC), the Electric Power Research Institute (EPRI), and B&W [6].

Parametric tests were performed to compare the combustion efficiency, sulfur capture, and agglomeration tendency of the three fuels [7]. The tendency of the mine-run and waste coals to agglomerate was of particular interest because of their high ash content and the presence of sodium and potassium in the ash [8]. Tests were run for a range of bed temperatures, calcium-to-sulfur (Ca/S) ratios, and stack oxygen content [9]. A cyclone was used as the primary separator rather than the B&W preferred U-beam separator to allow the results to be interpreted for the CFBC designs of most manufacturers [10]. The sorbent was a limestone from a Fairmount, Illinois, quarry [11].

The combustion efficiencies of all three fuels were similar to efficiencies obtained with other bituminous coals tested on the unit [12]. All three fuels could be combusted with acceptable CO, SO2, and NOx emissions [13]. The agglomeration that occurred with the mine-run coal was alleviated by increasing the bed drain rate and utilizing periodic bed dumps to remove small agglomerates [14].

ABSTRACT # 9
SNRB CATALYTIC BAGHOUSE LABORATORY PILOT TESTING

The SOx-NOx-Rox BoxTM (SNRB) process is a B&W patented, advanced air pollution control system that provides for significantly reduced SOx, NOx, and particulate emissions from coal-fired boilers [1]. The process utilizes a high-temperature catalytic baghouse for integration of SOx reduction through the injection of an alkali sorbent such as hydrated lime or sodium bicarbonate, NOx removal through ammonia injection and selective catalytic reduction, and particulate collection [2]. The advantages of the process include: compact integration of the emission control technologies into a single component, dry sorbent and by-product handling, and improved SCR catalyst life due to lowered SOx and particulate levels [3].

The SNRB concept has been successfully demonstrated in a 1500 ACFM pilot baghouse at B&W's Alliance Research Center [4]. This paper describes the SNRB technology and presents the SOx, NOx and particulate removal performance results over a range of operating conditions for the laboratory pilot test program [5].

ABSTRACT # 10
EXAMINATION OF MATERIALS EXPOSED IN A COAL-FIRED FLUIDIZED BED AIR HEATER EXCHANGER

The results of destructive examinations of uncooled and air-cooled specimens removed from an experimental coal-fired atmospheric limestone fluidized bed after exposures of about 500, 1000 and 2000 hours are reported [1]. The corrosion rates for twenty-three different materials were determined and these are to be used in conjunction with the results of samples removed from an in-bed heat exchanger to determine the materials to be used for the design of a commercial fluidized bed air heater [2]. The overall test conditions, sample descriptions and rankings of the alloys tested are presented [3]. Some generalizations concerning alloy composition are presented [4]. Apparently alloys containing high nickel and aluminum contents have poorer corrosion resistance and are not recommended for this application [5].

Plasma and flame sprayed coatings of FeCrAlY and CoCrAlY were tested but measurements of their corrosion was not possible and their adherence to substrates of TP 304H SS and alloy 800H was poor and would need to be improved for this application [6].

The corrosion rates of test welds were generally greater than many of the alloys and either other weld compositions or larger thicknesses would have to be used for this application [7].

ABSTRACT # 11
SHAPE MELTING TECHNOLOGY

Shape Melting is a process for manufacturing near net shape components entirely from incrementally deposited molten metal [1]. This process has been in development in Europe since the late sixties [2]. Babcock & Wilcox over the last five years has developed its own shape melting technology, primarily utilizing the gas metal arc welding (GMAW) process to deposit the metal [3]. The B&W approach employs robotic equipment, as compared to prior efforts which relied on hard mechanization techniques [4]. The program has focused on the development of techniques, auxiliary equipment, and strategies necessary to economically manufacture a wide variety of near net shape products [5]. Nickel base materials, such as Alloy 625 and austenitic stainless steels, have been the primary materials utilized to date [6].

This paper describes the shape melting technology developed by B&W [7]. B&W's approach to assuring a high quality weld deposit will be described [8]. Included is a description of the automation techniques and equipment for the manufacture of such components as flanged cylinders, hemispherical heads, and elbows [9]. In addition, the advantages of shape melting will be discussed, including the isotropic properties, fine grain cast structure, ultrasonic and radiographic quality, and chemical homogeneity achieved with this process [10].

ABSTRACT # 12
USING Ct TO PREDICT COMPONENT LIFE

Prediction of the remaining life of fossil power generation components from creep rupture data alone is not possible [1]. At the end of the predicted creep rupture life, cracks can develop at critical locations and then can propogate in time due to creep and ultimately cause failure of the component [2]. In the sub-creep temperature regime where crack growth is possible under elastic and elastic plastic loading, the fracture mechanics approach for predicting crack growth is well documented in the literature [3]. In LEFM-controlled fatigue crack growth, this parameter is the range of the stress intensity factor, DK [4]. In EPFM-controlled ductile crack growth (tearing), this parameter is the J-integral [5]. In time-dependent fracture mechanics (TDFM), the analogous crack tip parameter is the energy release rate (power) parameter, Ct, which correlates creep crack growth through the relationship:

$$da/dt = bCtq \quad [6]$$

The remaining life of a component with a pre-existing defect under creep conditions can be obtained by integrating the above relationship numerically [7]. The paper addresses the application aspects of this Ct parameter considering the effects on life prediction assuming plan stress versus plane strain and steady-state creep versus primary plus steady-state creep for various cracked geometries [8]. Lastly, cyclic versus continuous loaded components are discussed for typical fossil power plant main steam lines [9].

ABSTRACT #13
E-SOx 5-MWe PILOT DEMONSTRATION RESULTS

E-SOx is a coal-fired boiler retrofit SO2 emission control technology which involves modification of an existing electrostatic precipitator (ESP) to include a lime slurry atomization system [1]. SO2 emission reduction and particulate collection are performed in the modified ESP [2]. The relative simplicity of the retrofit makes E-SOx an attractive low-cost emission control option in applicable situations [3].

Development of the technology has progressed from small-scale pilot studies to a 5-MWe equivalent demonstration facility erected at a host utility site [4]. The demonstration project was sponsored by the Ohio Coal Development Office, the U.S. Environmental Protection Agency, Babcock & Wilcox and Ohio Edison [5].

The initial performance tests were completed in November, 1989 [6]. The SO2 removal performance observed in these tests was comparable to that of the pilot tests and dry scrubber performance at similar operating conditions [7]. Particulate collection efficiency was lower than expected due to the unexpected excessive reentrainment of ultrafine lime particles [8].

ABSTRACT # 14
EXPERIENCE WITH WATER SAMPLING AND CHEMISTRY MONITORING EQUIPMENT

In 1986, a project contracted by the Electric Power Research Institute (EPRI) was initiated whereby measurement of cycle chemistry parameters in a variety of boiler types and under a variety of test conditions was performed for comparison to the EPRI interim consensus guidelines [1]. To accomplish this task, a sophisticated chemistry monitoring system, which could be transported to several different power plants, was designed and fabricated [2]. This project allowed the opportunity to gain invaluable experience in the operation of on-line chemistry monitors [3].

One of the major findings of this program was that it brought to center stage many shortcomings of the on-line chemistry monitors and other equipment [4]. Therefore, many improvements were made in the calibration, maintenance, and operation of this equipment [5]. An alternate water supply and standard sample synthesizer became standard tools for determining the quality of the results obtained from the on-line monitors [6]. One of the most common findings was that the calibration frequency needed to be increased significantly (up to seven fold) to get accurate results [7]. The project also extended the useful temperature range of the cation resin membranes and identified a potentially serious problem regarding stress corrosion cracking of stainless steel sample coolers [8]. Most of the findings in this paper are applicable to the on-line monitors being used in the power industry today [9].

ABSTRACT # 15
LIMESTONE AND ITS ROLE IN NOx EMISSIONS IN THE AFBC PROCESS

A research program was conducted at the atmospheric fluidized-bed combustion (AFBC) facilities of the Babcock & Wilcox Company (B&W) Alliance Research Center to investigate coal and limestone interactions in the AFBC process [1]. The program was sponsored by the Consolidated Edison Company of New York, Inc. (Con Edison) and the Empire State Electric Energy Research Corporation (ESEERCO) [2]. This paper discusses the significant finding that NOx levels produced in the AFBC process varied dramatically for the limestone types utilized in the test program [3]. Tests were performed with six limestones and two coals under similar conditions in the 1-foot x 1-foot (1x1) AFBC facility [4]. High NOx levels were detected (600 to 1000 ppm versus 200 to 250 ppm for other limestones) when two dolomitic limestones were used in combination with two coals in the combustion process [5]. The impurities content in the limestone is suspected as being one factor contributing to the high NOx levels detected in the flue gas [6]. The dolomitic limestones contained approximately 16% MgO (by weight) as compared to less than 3% with the other limestones [7]. The dolomites also contained more iron than three of the other limestones [8]. Comparisons are made in this paper with the findings of other investigators [9]. Suggestions are also made concerning possible causes of the NOx emission variations and areas where further research may be done [10].

The discovery that NOx emissions vary with limestone type in the AFBC process is of major importance [11]. It is expected that more stringent NOx emission standards will be imposed in the near future [12]. Research that involves the cause of high NOx level production may provide possible criteria important to the future selection of limestones for AFBC applications [13].

ABSTRACT # 16
SIMULTANEOUS SOx/NOx/PARTICULATE REMOVAL IN A HIGH TEMPERATURE BAGHOUSE

The SOx-NOx-Rox BoxTM (SNRB) process is a Babcock & Wilcox (B&W) patented advanced air pollution control system that provides for significantly reduced SOx, NOx, and particulate emissions from coal-fired boilers [1]. The process utilizes a high-temperature catalytic baghouse for the integration of SOx reduction through the injection of an alkali sorbent such as hydrated lime or sodium bicarbonate, NOx removal through ammonia injection and selective catalytic reduction, and particulate collection [2]. The advantages of the process include: compact integration of the emission control technologies into a single component, dry sorbent and by-product handling, and improved SCR catalyst life due to lowered Sox and particulate levels [3].

Emission control performance of the SNRB concept has been successfully demonstrated in an integrated, 1500 ft3/minute capacity pilot baghouse at B&W's Alliance Research Center [4]. The test results have been used to develop design, performance, and operation specifications for a 5 MWe demonstration facility currently under construction at a commercial utility site [5]. The facility will be used to generate information needed for commercialization of the SNRB technology [6].

ABSTRACT # 17
ON-LINE IMAGING AND EMISSIVITY MEASUREMENTS TO DETERMINE FURNACE CLEANLINESS

High furnace exit gas temperatures (FEGT), excessive pendant and convection surface pluggage, high superheater and reheater attemperation spray flows, high economizer gas outlet temperatures, and ineffective cleaning are some of the difficulties encountered in boilers burning Power River Basin (PRB) coals [1]. In most cases, the cause of these problems can be traced to the highly reflective ash deposited in the furnaces burning these coals [2].

In this paper, we report the development of on-line diagnostic tools to identify and quantify the performance impact caused by reflective ash deposits in utility boilers [3]. Use of these new devices will allow performance engineers and boiler operators to assess lost furnace heat transfer absorption capacity, furnace cleanliness, cleaning equipment changes required to regain reduced capacity, performance of cleaning devices and when and where furnace cleaning is required [4].

ABSTRACT # 18
NUMERICAL MODELS AS COMBUSTION SYSTEM DESIGN TOOLS

Environmental regulations for fossil fuel boiler systems are becoming more stringent [1]. With an increasing emphasis on the use of staged combustion to lower emission levels and the need to maintain plant availability for these complex combustion systems, conventional, empirically-derived design criteria cannot be easily extended beyond the established "design envelope [2]." As a result, Babcock & Wilcox (B&W) has developed mathematical models to enhance design capabilities for these advanced combustion systems [3]. The models vary in complexity from three-dimensional models that require expert users and workstation computers to one-dimensional models that run on personal computers (PCs) [4]. Several examples are presented in this paper demonstrating the use of B&W's numerical models in staged combustion system design [5].

ABSTRACT #19
PERFORMANCE COMPARISON OF BABCOCK & WILCOX COMMERCIAL CIRCULATING FLUIDIZED BED BOILERS

The Babcock & Wilcox (B&W) Company implements commercial circulating fluidized bed (CFB) boiler technology for a wide range of fuels including wood, a variety of sludges, and coal [1]. The original technology was provided under a license agreement with Studsvik AB of Sweden [2]. Studsvik began development of the technology in 1977 [3]. An overview of B&W's research and development (R&D)facilities and two coal-fired commercial units is presented in this paper [4]. The B&W CFB boiler development program is supported by several test facilities at the Alliance (Ohio) research center beginning with fixed-bed and fluidized-bed bench-scale facilities, extending through a CFB cold model and a small 0.25 MW, CFB combustor, and culminating with a full-height 2.5 MW, CFB pilot facility [5]. B&W has built coal-fired CFB boilers for Lauhoff Grain in Danville, Illinois, and Ebensburg Power Company in Ebensburg, Pennsylvania [6]. The Lauhoff Grain CFB is designed to produce 28.45 kg/s (225,800 lb/hr) of steam and burns a high-sulfur bituminous coal [7]. The Ebensburg unit is designed to produce 58.9 kg/s (465,000 lb/hr) of steam and burns a bituminous coal waste [8].

Performance data from the two commercial units and the 2.5 MW pilot facility are presented and compared [9]. The commercial units meet or exceed the design requirements for steam production and gas emissions [10]. The 2.5 MW,CFB is shown to be a powerful tool that B&W can use for the future development of CFB technology [11].

ABSTRACT # 20
REBURNING SCALE-UP METHODOLOGY FOR NOx CONTROL FROM CYCLONE BOILERS

There are currently no commercially-demonstrated combustion modification techniques for cyclone boilers which reduce NOx emissions [1]. The emerging reburning technology offers cyclone boiler owners a promising alternative to expensive flue gas cleanup techniques for NOx emission reduction [2]. Reburning involves the injection of a supplemental fuel (natural gas, oil, or coal) into the main furnace in order to produce locally reducing stoichiometric conditions which convert NOx produced in the main combustion zone to molecular nitrogen, thereby reducing overall NOx emissions [3].

After obtaining encouraging results from an engineering feasibility and pilot-scale proof of concept studies (1,2), Babcock & Wilcox is presently working on a DOE Clean Coal II project to prove the cyclone coal technology at the full-size utility boiler scale [4]. The host site for the demonstration is the Wisconsin Power & Light (WP&L) company's 100 MEw Nelson Dewey Station [5].

This paper discusses the scale-up methodology from 6-million Btu/hr pilot-scale to the Nelson Dewey Station [6]. This methodology involves:

- pilot-scale evaluation with the demonstration coal
- baseline measurements at the host site boiler, including velocity and temperature profiles combustion, and emissions characterization
- mixing optimization utilizing physical and numerical modeling [7].

ABSTRACT # 21
TECHNICAL CONSIDERATIONS IN USING LOW-SULFUR-FUEL SWITCHING AS A CLEAN-AIR-ACT COMPLIANCE OPTION

Fuel switching from high-sulfur coal to a low-sulfur fuel, such as gas, oil, or coal, represents a key option when developing a compliance strategy to meet the SO2 emission control requirements of the Clean Air Act

Amendments of 1990 [1]. However, large coal-fired utility boilers in service today have been custom designed for selected fuels; changing the fuel may have significant impacts on the reliability and operation of not only the boiler itself but also on many of the supporting systems [2]. This paper explores the various technical factors which should be considered in the decision to fuel switch [3].

From a boiler perspective, these factors include, but are not limited to, furnace absorption, fouling and slagging, cleaning equipment, heat transfer surface changes, boiler efficiency changes, and derates [4]. Key support systems include particulate control equipment, fuel preparation, and combustion as well as fuels and material handling [5]. Selected indices and measures are discussed which aid in the evaluation of the effects of fuel changes [6].

ABSTRACT # 22

SELECTION OF A WELD JOINT CONFIGURATION FOR PLASMA ARC WELDING OF HP-9NI-4Co-0.30C ASRM CASING STEEL

The advanced solid-rocket motor (ASRM) cases for the space shuttle will be manufactured from HP-9Ni-4Co-0.30C alloy steel [1]. This alloy steel was selected as the casing material, in part, because of its good welding characteristics [2]. A preferred weld joint configuration for keyhole plasma arc welding (PAW) of HP-9Ni-4Co-0.30C steel was selected based on a relatively new experimental test procedure that evaluates welding parameters [3].

The experimental test procedure incrementally stepped the plasma gas flow rates, linearly increased the welding current within each step, but kept constant the travel speed, arc length, torch angle, and set-up conditions [4]. This methodology was used to weld HP-pNi-4Co-0.30C steel plates with various weld joint designs [5]. Post weld visual examination of the welded joints revealed distinct modes of weld bead geometry which were indicative of the welding current for each plasma gas flow rate [6]. Acceptable weld bead geometries are defined as those having acceptable bead contour and minimal weld drop-through [7]. Using these criteria, a graphical representation of this data yields an operational window within which good welds are produced [8].

Three fundamental joint configurations--U-groove, V-groove, and butt joint--with various land thicknesses, radii, or angle were evaluated [9]. Results showed some major difference in the ability to produce acceptable welds depending on the joint configuration [10]. Therefore, the relative size of the operational envelope with welding parameters that produced acceptable welds was used to systematically help select three candidate joint designs at different land thicknesses [11]. The keyhole and melt-in modes of the candidate joint designs were further characterized with additional operational window testing techniques [12]. The three candidate joint designs used a U-groove at the 0.312-inch and 0.375-inch lands and a truncated V-groove at the 0.437-inch land [13]. Results from their operational windows, mechanical property tests, and the qualities of the weld procedure developed were used to select the preferred ASRM weld joint design [14]. The preferred weld joint design was the V-groove at the 0.437-inch land [15]. This joint design uses a three-pass weld procedure--an autogenous root pass with two fill passes [16]. Overall, this design had good material properties, the least distortion, a low susceptibility to producing defects, good machinability, fit-up, and inspectability [17].

ABSTRACT # 23

PILOT-SCALE DEMONSTRATION OF THE LIDS SYSTEM FOR LOW-COST BOILER POLLUTION CONTROL

This paper describes the results of a pilot-scale demonstration of the LIDSTM process sponsored by the Ohio Coal Development Office (OCDO) and the Babcock & Wilcox Company (B&W) [1]. LIDS (Limestone Injection with Dry Scrubbing) combines the technologies of furnace sorbent injection and dry scrubbing [2]. The result is a reduction of reagent costs and an increase in sorbent utilization and sulfur dioxide (SO2) removal beyond what is possible if the technologies are used separately [3]. By combining dry scrubbing with furnace sorbent injection, limestone can be used as the reagent and the process is applicable to higher sulfur coals [4]. This is possible because the reaction that occurs during furnace injection significantly reduces the SO2 concentration entering the dry scrubber; the unused limestone from the furnace injection is calcined to lime and makes an excellent dry scrubbing reagent [5].

The goal of the project was to demonstrate that LIDS could achieve high levels of SO2 removal (>90%) on high-sulfur (3.0 to 3.5% by wt.) coal using only limestone as the reagent [6]. The pilot-scale test facility consisted of a 1.8 x 106 J/s (6.0 x 106 Btu/hr) cyclone combustor, a 9.1 m (30 ft) long by 1.5 m (5 ft) diameter vertical down-flow dry scrubber, baghouse, and simple detention slaking tank [7]. This project studied how SO2 removal is affected by injection temperature, limestone composition, scrubber approach to saturation temperature (Tas), and limestone feed rate [8].

The LIDS equipment performed very well throughout the project [9]. Minimal deposition occurred on the walls of the scrubber even at a Tas below 11.1 degrees C (20 F) [10]. Testing at a Tas of 11.1C and a furnace Ca/S ration (moles of calcium fed to the furnace divided by the moles of SO2 in the flue gas) of 2.4 while using calcite showed that over 90% SO2 removal was achieved across the furnace and scrubber, over 95% SO2 reduction was achieved when the baghouse removal was included [11]. The project successfully demonstrated that LIDS is a viable, low-cost option for controlling SO2 emissions from existing coal-fired utility boilers [12].

ABSTRACT # 24
FIELD TEST RESULTS ON FIBER OPTIC PRESSURE TRANSMITTER SYSTEM

The performance of a pressure transmission system containing a microbend fiber optic pressure transducer is reported [1]. The pressure transducer design is described along with the configuration for its installation in a coal liquefaction reactor operating at 3000 psi pressure and temperatures up to 840 degrees F [2]. The modulated light intensity signal proportional to pressure is transmitted to the remote optoelectronic signal conditioner 250 feet from the reactor [3]. The results of a one-month field test to be reported include the calibration, measured pressure versus time, thermal and pressure cycling data, and failure mode [4].

ABSTRACT # 25
THE IMPACT OF PRESS DESIGN ON SKIN-YOKE/COLLAR PRESTRESS IN SSC COLLIDER QUADRUPOLE MAGNETS

The SSC collider ring quadrupole magnets use a cold iron yoke and skin for mechanical support of the collared coil assembly [1]. These components together constitute the cold mass [2]. In the assembly process, an hydraulic press is used to compress two skin and yoke halves against the collared coil assembly [3]. The skin is pressed tightly around the yoke and coil and is welded longitudinally [4]. Weld shrinkage tensions the skin circumferentially at room temperature [5].

Two basic press designs are considered for the skinning process; a single axis (solid die form) press and a radial distribution (bladder) press [6]. The interaction of the skinning press and the cold mass is simulated for both cases by finite element methods [7]. The computed displacements and stresses on the quadrupole magnet components are presented [8]. The cold mass is evaluated for assembly process effects and for the effects of subsequent cooling to 4K [9]. The adequacy of the interference fit between the iron yoke and aluminum collar is checked [10]. The advantages and disadvantages of the two presses are summarized [11].

ABSTRACT # 26
FIELD TEST PROGRAM TO CHARACTERIZE EMISSIONS AND PERFORMANCE OF WOOD-FIRED BOILERS

Wood-fired boilers have a long history with the forest products industry, where they serve to reduce wood-waste inventory while supplying steam for process needs [1].

The most common type of wood-fired boiler today is the spreader stoker, where fuel is spread over a grate at the bottom of the furnace [2]. Combustion is supported by separate streams of overfire and undergrate air [3].

Predicting the combustion-related performance of wood-fired boilers is challenging, since for any given operation, the moisture content, heating value and mesh size of the fuel feed typically varies significantly from day to day, or even hour to hour [4]. At the same time, recent changes to North American environmental regulations have resulted in both lower stack emissions limits, and the addition of clarifier sludge and other pulp mill wastes to the range of wood-waste fuels [5].

Babcock & Wilcox has begun a program to characterize combustion performance and emissions over a range of wood and wood-waste fuels [6]. The program will span several years and includes both collection of field data and refinement of a proprietary three dimensional mathematical model [7].

This paper will highlight field test results, to date [8].

ABSTRACT # 27
SUMMARY OF FAILED REACTOR COOLANT PUMP ROTATING ASSEMBLY EXPERIENCE AT CRYSTAL RIVER UNIT 3

Four reactor coolant pump (RCP) rotating assemblies (shafts) have failed or have severely cracked during operation at the Crystal River Unit 3 (CR-3) Nuclear Power Plant [1]. Inspections performed during 1986 and 1989 found two failed shafts in RCP-1A (one in 1986 and one in 1989) [2]. Inspections performed during 1986 and 1990 found two cracked shafts in RCP-1B and RCP-1D, respectively [3]. The two failed shafts removed from RCP-1A have been extensively examined; the cracked shaft removed from RCP-1B (1986) was non-destructively examined at the CR-3 site and the shaft removed from RCP-1D (1990) is currently being examined [4]. All of the RCPs were manufactured by Bryon Jackson Pump Division of Borg-Warner Industrial Products, Inc [5]. All of the RCP shafts (except the D shaft) were fabricated from UNS S66286 superalloy (Alloy A-286) [6]. The D shaft was fabricated from UNS S20910 (Alloy XM-19/Nitronic 50) [7].

Torsional strain gauge analysis was performed on the RCP-1A shaft during the 1990 refueling outage [8]. This type of analysis has not been performed previously on an operating RCP [9]. Several results were found including: (1) the primary components of alternating torsional stress during normal RCP operation are impeller vane pass and a sub-2X torsional resonance with maximum components of plus or minus 0.8 ksi; (2) a typical vane pass cycle is initiated by an abrupt unloading of the shaft followed by a reload past equilibrium and a damped return to equilibrium; (3) a higher (compared to normal four pump operation) alternating torsional stress range resulted from the solo operation of RCP-1A at low temperature and pressure (normal startup conditions); (4) the 2/0 combination produced the highest mean torsional stresses and the lowest alternating stresses and (5) a startup of a secured RCP with three operating pumps results in significantly higher alternating stress than a cold startup [10].

The root cause RCP failure mechanism appears to involve RCP startup sequence at CR-3, peculiarities that necessitate this sequence and complex shaft stresses just above or under the journal bearing [11]. The 1986 impeller bolt failure is not considered to be a root cause effect [12]. It was also determined that fatigue cracking has always been responsible for both shaft initiation and propagation mechanisms and cracking can occur independent of shaft material [13].

ABSTRACT # 28
EFFECT OF REFRACTORY EMITTANCE IN INDUSTRIAL FURNACES

Heat transfer to the load in high temperature industrial furnaces is dominated by radiation from the flame and refractory walls [1]. Controlling the emittance of the walls should result in increased heat transfer to the load which should improve the furnace efficiency and productivity [2]. This paper presents the results of a study conducted to understand and quantify the role of refractory emittance on heat transfer to the load in industrial furnaces [3].

High temperature spectral emittances of untreated refractories and a variety of commercially available coatings were measured [4]. The range of emittances measured was 0.3 to 0.9 [5]. A lab furnace capable of simulating batch and continuous furnace operations was rebuilt for the experimental evaluations of emittance coatings [6]. Test results indicate that batch furnaces with direct firing will not benefit from commercially available controlled emittance coatings [7]. Also, continuous furnaces with direct firing will have increased load heat flux with high emittance coatings [8]. A computer code developed to model spectral radiation in industrial furnaces was used to parametrically evaluate the effects of emittance on load heatup [9]. Predictions qualitatively follow the same trends as the experimental data [10].

ABSTRACT # 29
INSPECTION OF PIPE COVERED WITH MARINE GROWTH

Undersea inspection of pipelines and support structures is very difficult at best because of accessibility problems [1]. An additional problem is the accumulation of marine growth on the surfaces of the component to be inspected [2]. In order to apply UT, MP or EC methods, the marine growth must be completely removed at considerable cost [3]. A study has been conducted to evaluate methods of inspecting such components without removal (or with minimal removal) of the marine growth [4]. A method is described using EMAT (Electromagnetic Acoustic Transducer) Lamb wave method to inspect a large pipe by removing only a narrow strip of the marine growth for access [5]. It has also been shown that DPEC (Deep Penetrating Eddy Current) technique can be used for inspection of a pipe completely covered by a 2" thick layer of marine growth [6]. In both cases, simulated defects resembling those referenced in applicable industry inspection codes were detected in a pipe sample with the two methods [7].

ABSTRACT # 30
COAL--RETROFITTING AND REPOWERING FOR FUTURE USE

Projections of future electrical energy production all seem to indicate that coal will continue to play a major role [1]. Today's experimentation will lead to tomorrow's environmentally acceptable application of coal [2]. Today's work involves retrofitting and repowering technologies for present systems to allow their continued use [3]. These present studies are also aimed at determining what changes might be required for units to be built in the future [4]. We will discuss Babcock & Wilcox's approach to both the near and far term by presenting a progress report on programs aimed at providing environmentally acceptable coal-fired systems [5].

ABSTRACT # 31
SITE LOGISTICS AND THE IMPACT ON PFBC DESIGN

Because it operates under pressure, a Pressurized Fluidized Bed Combustion (PFBC) boiler is physically smaller than an atmospheric boiler of the same capacity [1]. It therefore offers the opportunity to maximize the amount of work done in the fabrication shop and to reduce the amount of field construction work completed at the power plant site, thus reducing both construction spans and total plant costs [2].

Attempts to make the maximum use of off-site fabrication of a PFBC plant brought into play a number of factors which are not normally major considerations in the design of a power plant [3]. Some of those factors are barge accessibility, crane capacity, floor to hook crane heights, navigable channel depths under bridges, and multi-wheeled vehicle stability [4]. This paper presents a case study of how these and other factors effected the design of a 70 MWe PFBC power plant [5].

ABSTRACT # 32
APPLICATION OF STATISTICAL PROCESS CONTROL TECHNIQUES FOR INSTRUMENT EVALUATION

A technique is presented which utilized instrument redundancy and statistical quality control techniques in order to provide information on instrument performance and data quality [1]. Currently, instrument certification is provided by pre-test, post-test, and set-interval calibrations to ensure the quality of data during a test program [2]. This study investigates an alternative method of providing data quality assurance through the application of Statistical Process Control (SPC) techniques to multiple instrument sets which provide for measurement redundancy [3]. It is demonstrated that SPC techniques can be used to provide predictive information on instrument failure and a history of the instruments behavior within a group [4]. In addition it is demonstrated that SPC techniques can provide an alternative to post test calibrations for de-certification at the end of a test program [5].

ABSTRACT # 33
THE SELECTION OF DISCRETE ORDINATE QUADRATURE SETS FOR ANISOTROPIC SCATTERING

This paper presents numerical quadrature for use in both one and multi-dimensional discrete ordinates methods with anisotrophic scattering [1]. The present paper presents new level symmetric and equal weight quadrature (direction cosines and weights) that not only integrate the important integrals in the radiative transport equation and the boundary conditions, but accurately satisfy some higher order moments of many complex phase functions [2]. Examples demonstrate the accuracy of the quadrature sets to simulate several phase functions [3]. Two-dimensional modeling shows that converged solutions can be found when the quadrature are selected to integrate the moments for the incident energy, heat flux, and diffusion condition, as well as the phase function [4].

ABSTRACT # 34
CERAMIC COMPOSITES AS CLADDING FOR WATER REACTOR FUEL ELEMENTS

The feasibility of applying continuous fiber ceramic composites in place of Zircaloy as cladding for commercial water reactor fuel elements is presented [1]. Mechanical and thermal properties of a filament wound alumina-zirconia composite are presented and compared with Zircaloy at normal reactor operating conditions [2]. Results of initial fabrication development are also presented [3]. The expected behavior of ceramic composite fuel element cladding during a hypothetical severe loss of coolant accident is compared with the predicted behavior of Zircaloy clad fuel elements during the same accident [4]. It is shown that the ceramic composite is significantly more resistant to damage than the Zircaloy, retains its strength at temperatures exceeding 200F and is inert in high-temperature steam, thus avoiding the production of hydrogen gas [5]. Implications to the design, performance and severe accident behavior of composites in place of Zircaloy would substantially reduce the threat to containment integrity of such accidents [6]. This could lead to significant reduction in risk for currently licensed reactors, as well as simplification, cost reduction, and improved safety for advanced water reactors [7].

Near-term development and testing needs to confirm the feasibility of using continuous fiber oxide-based ceramics for fuel element cladding are outlined [8].

ABSTRACT # 35
CYCLONE FURNACE FOR VITRIFICATION OF CONTAMINATED SOIL AND WASTES

The Babcock & Wilcox (B&W) cyclone vitrification furnace appears well suited to treating high-inorganic-content hazardous wastes (e.g., soils) which exist at many Superfund sites [1]. In a study performed under the U.S. Environmental Protection Agency (EPA) Superfund Innovate Technology Evaluation (SITE) Emerging Technologies Program, the B&W 6-million Btu/hr pilot-scale cyclone furnace was used to vitrify an EPA Synthetic Soil Matrix (SSM) [2]. The SSM was spiked with 7000 ppm lead, 1000 ppm cadmium, and 1500 ppm chromium, and was then fed at nominal rates of 50 and 150 lb/hr tangentially into the cyclone furnace [3]. The soil is captured and melted in the molten slag layer, then exits the cyclone furnace, and finally is dropped into a water-filled slag tank where is solidifies [4]. The vitrified soil was non-leachable [5]. Average lead, cadmium, and chromium toxicity characteristic leaching procedure (TCLP) leachabilities in the treated SSM tests at SSM feed rates of 50 and 150 lb/hr were 0.19, 0.12, and 0.08 mg/L, respectively [6]. These results are well below EPA limits [7]. The capture of heavy metals in the vitrified slag is estimated at 8 to 17% for cadmium, 24 to 35% for lead, and 90 to 95% for chromium [8]. The capture of heavy metals in the slag increased with increasing soil feed rate and increased with decreasing metal volatility [9]. Additionally, the volume of the vitrified soil was reduced by approximately 35% when compared to the dry SSM [10].

ABSTRACT # 36
USE OF EMATS FOR INSPECTION OF ADVANCED SOLID ROCKET MOTOR CASINGS

Current requirements specify that the Advanced Solid Rocket Motor (ASRM) case material and the weld surfaces be examined by fluorescent magnetic particle (MT) examination techniques [1]. Because magnetic particle inspection does not lend itself easily to automated inspection and is often dependent on subjective interpolation, a different approach based upon ultrasonic methods utilizing electromagnetic acoustic transducers (EMATs) was identified as an acceptable replacement for the magnetic particle method [2].

To verify the EMAT technology for HP-9Ni-4Co-0.30 alloy steel, a feasibility study was conducted [3]. A heat treated sample of the steel containing six EDM notches was fabricated [4]. Laboratory EMAT equipment, using both pulsed and permanent magnet transducers, was utilized in this study [5]. Both surface wave and shear wave angle beam techniques were evaluated [6]. In addition, pulse-echo and transmission techniques were used [7].

The feasibility study demonstrated that all simulated defects located on one surface were readily detected from the same side using surface wave EMATs [8]. Surface flows located on both sides of the sample could be detected from one side using SV (shear) waves [9]. By using pulsed magnets, EMATs easily lend themselves to automation and eliminate the need to interpret visual information from traditional MT inspection [10].

ABSTRACT # 37
ABSOLUTE FIBER OPTIC PRESSURE TRANSDUCER FOR AIRCRAFT AIR DATA MEASUREMENT

In this paper, we present the design rationale for a total pressure fiber optic transducer under development for planned flight test [1]. Pressure sealing problems for absolute pressure transduction are discussed [2]. Information is given on the microbend fiber optic sensor approach used to measure diaphragm deflection, and requirements for microbend sensor thermal compensation [3]. Wavelength division multiplexing approaches are described to self-reference the fiber optic sensors so that the transducer output is insensitive to interconnect cable bending and connector mating/demating [4]. Requirements and constraints imposed by the wavelength division multiplexing methods are discussed, along with the impact on overall transducer operation [5]. Preliminary performance data is presented on a prototype transducer incorporating the features necessary to achieve a stable, repeatable, and accurate output [6].

ABSTRACT # 38
CORROSION EFFECTS OF HIGH DEPOSIT LOADINGS DURING NUCLEAR SYSTEM GENERATOR CHEMICAL CLEANING

The current chemical cleaning galvanic corrosion database was developed for a magnetite loading of 17.5 g/L of solvent [1]. The actual loading at different steam generators could vary appreciably from the standard 17.5 g/L loading [2]. Higher loadings could have a significant impact on the corrosiveness of the solvent system [3]. As part of their chemical cleaning program, B&W performed a series of tests to quantify the effects of higher deposit loadings on free and galvanic corrosion during chemical cleaning [4]. This evaluation demonstrated that increasing deposit loading increases the corrosion of the carbon steel materials tested [5]. Both dissolution rate and total dissolved species affect the corrosion and must be considered in qualifying a process for a specific plant application [6]. Dissolution data with actual steam generator plant deposits was obtained in this test program along with the corrosion data [7]. The dissolution data indicated that the higher loadings can also affect the solvent efficiency in dissolving deposits and must be considered in a qualification program for a specific plant [8]. The results of this test program are presented in this paper [9].

ABSTRACT # 39
COAL DEVOLATILIZATION AND CHAR OXIDATION UNDER SIMULATED PRESSURIZED FLUIDIZED-BED COMBUSTION (PFBC) CONDITIONS

Pressure affects the efficiency of the carbon conversion and sulfur capture [1]. It also affects the composition of the coal devolatilization products [2]. Therefore, fundamental information on pressurized fluidized-bed combustion (PFBC), particularly the combustion kinetics, is important to the design of commercial PFBC units [3].

A fundamental study sponsored by the U.S. Department of Energy/Morgantown Energy Technology Center (DOE/METC) investigated the influences of total pressure, temperature, gas velocity, oxygen concentration, coal particle size, and coal type on coal combustion using a bench-scale facility [4]. The information is needed to support the PFBC advanced-concept work being conducted for DOE [5].

The work involved fabrication and installation of a bench-scale pressurized reactor facility [6]. The bench-scale facility is designed to operate up to 1800 degrees F, 300 psig, and a superficial gas velocity of 20 ft/sec [7]. All the tests were performed in a fixed-bed mode [8]. Several sizes of coal were tested at four pressures, three temperatures, two oxygen concentrations, and four gas velocities [9]. Over 400 combustion tests were performed on Pittsburgh No. 8 coal [10].

Combustion profiles were determined based on the test data [11]. A global type kinetic model was developed [12]. The reaction rates for coal devolatilization and the rate constant and the activation energy for char oxidation were derived using the model [13].

For coal devolatilization of Pittsburgh No. 8 coal, the rate of devolatilization increased with increasing oxygen concentration, increasing gas velocity, and decreasing particle size [14]. However, the rate of devolatilization did not have a linear relationship with temperature and pressure [15]. The orders of reaction were found to be less than one [16].

For char oxidation, the kinetic rate constant increased with increasing temperature, pressure, and gas velocity [17]. However, it was not affected by coal particle size [18]. The apparent order of reaction was less than one [19]. The activation energy of Pittsburgh No. 8 coal was approximately 11.2 kcal/g-mole (or 4.69% 107 joule/kg-mole) with a frequency factor of approximately 0.043 gm of carbon/cm2-sec-(atm)0.2 (or 0.43 kg of carbon/m2-sec-[atm]0.2) when combusted at 206 psig, 3% 02, and a gas velocity of 4 ft/sec [20].

ABSTRACT # 40
PARAMETRIC STUDY AND DYNAMIC ANALYSIS OF COMPLIANT PILED TOWERS

A Compliant Piled Tower (CPT) consists of two main structural components, the piles and the tower [1]. Different configurations of CPT were studied in the present paper [2]. The mechanical system of restoring forces was based on the coupling that provides dynamic balance between the piles and the tower [3]. A parametric analysis was conducted to determine the variation of the first and second natural periods with parameters such as pile length, base width, deck payload, water depth, and pile area [4]. The dynamic behavior of the CPT was studied for various prototypes [5]. Response characteristics of the structure to a random wave derived from a characteristic wave spectrum were studied [6]. Envelopes of overturning moment and shear force for different sea states were studied as well as the derivation of such envelopes from corresponding profile at various instances [7].

ABSTRACT # 41
NOx EMISSION STUDIES IN FLUIDIZED-BED COMBUSTION

Circulating fluidized-bed combustion (CFBC) has grown in popularity due to low pollutant emission levels, improved turndown capabilities, fuel flexibility, and good solids mixings [1]. However, recent CFBC operating results at various facilities has shown increased NOx emission levels when utilizing increasing amounts of sorbent [2]. Current studies performed at the Babcock & Wilcox Alliance Research Center have shown similar results with atmospheric fluidized-bed combustion (AFBC) [3]. NOx emissions were found to vary dramatically for the different sorbents utilized with similar calcium-to-sulfur ratios, but different sorbent/fuel ratios [4]. However, some sorbents also showed more affinity to NOx production than others [5].

This paper details current NOx emission studies utilizing three different sorbents (Lowellville limestone, Marblehead limestone, and Genstar dolomite) in a 6: Bench-Scale AFBC Apparatus [6]. Results indicated that NOx emissions were greatly influenced by the batch weight of the sorbent feed [7]. When small amounts of sorbent (50 grams) were introduced into the unit batchwise, no apparent effect on NOx emissions was realized with either Marblehead or Genstar sorbents [8]. When large amounts (680 grams) of each of the three sorbents were fed into the unit, substantial NOx emissions (>700 ppm) were detected initially for all three sorbents [9]. However, for Genstar dolomite, a high level of NOx emissions was maintained for a longer period of time as compared to the other two sorbents [10]. Since dolomites generally contain less CaO than limestones, tests performed with equal calcium-to-sulfur rations would utilize more dolomite [11]. Indeed, tests performed with equal calcium-to-sulfur rations of Marblehead limestone and Genstar dolomite showed considerably higher NOx levels with Genstar dolomite than with Marblehead limestone [12].

Overall, NOx levels were found to be influenced in part by the weight of sorbent used [13]. However, with equal weights (different calcium-to-sulfur ratios) of sorbent, NOx emissions with Genstar dolomite still remained somewhat higher throughout the steady-state test period that NOx emissions found with Marblehead and Lowellville limestones [14]. The reason(s) for this is yet unclear [15].

ABSTRACT # 42

FOULING AND CLEANING OF A STAGGERED, FINNED TUBE BUNDLE UNDER COAL-FIRED CONDITIONS

A unique test program was conducted to evaluate fouling and cleaning performance characteristics of a heat exchanger tube bundle for application to coal-fired boilers [1]. The test bundle contained helically finned tubes in a staggered arrangement [2]. Air sootblowers were installed upstream and downstream of the test bundle to evaluate cleaning effectiveness during the fouling test [3]. The bundle was installed in the outlet flue of a coal-fired test boiler to simulate flue gas and friable fly ash conditions of a pulverized-coal-fired utility or industrial boiler [4].

Thermal and hydraulic performance characteristics were measured to determine the effects of fouling and sootblower cleaning on bundle heat transfer and pressure drop [5]. Results showed that ash deposits were controllable by sootblowing and that the bundle did not plug [6]. The maximum fouling factor depended on sootblowing frequency, and there was no measurable increase in bundle pressure drop [7]. Fouling factor data were correlated against time, bundle geometry,and flue gas conditions for the two coals tested [8].

ABSTRACT # 43
NDE OF CERAMIC HEAT EXCHANGERS

Nondestructive Evaluation (NDE) is needed both to support the modeling for the initial design of ceramic components and to perform acceptance testing of the finished parts [1]. Results of development of NDE techniques for ceramic heat exchangers are presented [2].

ABSTRACT # 44
PROGRESS REPORT ON AN INVESTIGATION OF FEEDWATER FLOW MEASUREMENTS AT NUCLEAR POWER PLANTS

Deposit-related problems with feedwater flow measurements occur at some nuclear power generating plants resulting in an estimated loss of capacity of 2% over a fuel cycle [1]. The accumulation of deposits within feedwater flow venturis results in unknown changes in the venturi calibration [2]. Since the changes are in the conservative direction, it is not considered a safety problem [3]. B&W is investigating this operational problem by (1) surveying 30 plants and (2) conducting detailed examinations of venturis and venturi deposits at 3 plants under contract from the Electric Power Research Institute (EPRI) [4]. This paper is a progress report on that effort and the preliminary results of the examinations and samplings are summarized [5]. As expected the major crystalline constituents of the deposits are iron oxides (Magnetite and hematite) [6]. Calcium hydroxyapatite [Cas(PO4)3(OH)] is a minor crystalline constituent in the deposits at one plant [7]. Major elemental constituents are iron and oxygen (iron oxides) [8]. Other minor elements present in the deposits are calcium, carbon, silicon, aluminum, and titanium [9]. Nickel and chromium were found in some deposits resulting from the stainless steel base metal [10]. Accumulation of deposits is non-uniform and the deposition patterns vary for differing venturi designs [11]. Thicknesses range up to 400 microns in the sampled venturis and vary significantly from plant to plant [12].

ABSTRACT # 45
ADVANCED NDE TECHNIQUES FOR FOSSIL-FIRED BOILERS

This paper summarizes the planned scope of work and the results to date of the multi-year EPRI Project RP1865-10, "Improved Boiler Inspection Systems" [1]. The project encompasses the inspection of a variety of boiler components including furnace water walls, high temperature pendant reheaters and superheaters, horizontal tube banks and complex geometric shapes such as tees, wyes, headers and valves [2]. NDE (Nondestructive Examination) techniques to detect and/or characterize the following boiler tube failure problems are addressed - tube wall thinning, hydrogen damage, internal oxide scale buildup, corrosion fatigue cracks, internal tube deposits and tube wall distortion [3]. Technologies to assess these problems include remote sensing fixtures and delivery systems, Electromagnetic Acoustic Transducers, or EMATs, and miniature video equipment [4].

Emphasis in this paper will be placed on the results of work currently underway [5]. Preliminary design of a furnace wall inspection system to automatically measure tube wall thinning is described [6]. The design and evaluation of an eddy current probe for ID oxide thickness measurement in superheaters and reheaters is also reported [7]. Other work that has been initiated will be treated with less detail [8].

ABSTRACT # 46
ACOUSTIC EMISSION MONITORING OF HIGH ENERGY PIPING

Following the two incidents of failure of longitudinally welded hot reheat lines, the utility industry began extensive inspections of high-energy piping [1]. Many problems have been discovered, including cracked welds, improper materials, and improper support systems [2]. The inspections also identified many indications that have been present and innocuous since manufacture of the pipe [3].

Since the primary method of inspection is ultrasonic, scaffolding and removal of piping insulation is required [4]. The costs of this UT inspection can range from $400 to $1500 per foot of weld inspected [5]. EPRI developed project RP1893-4 to investigate effective alternative means of inspecting steam lines [6].

Early work on the project and the experience of others allowed an early conclusion that acoustic emission (AE) testing is the best candidate technique for overall condition monitoring and flaw detection and location [7]. AE development work carried out under RP1893-4 has involved both in-plant and laboratory testing [8]. In addition to in-plan tests carried out with project funding, liaison has been maintained with those utilities and testing services performing independent AE testing of steam lines [9]. The results of the plant and laboratory tests, as well as utility sponsored testing, will be presented along with an overview of the guidelines generated to assist utilities in determining whether to use AE testing how this testing should be completed [10].

ABSTRACT # 47

ASSESSMENT OF AUTOGENOUS TYPE 410S STAINLESS STEEL WELDS IN REPLACEMENT STEAM GENERATOR TUBE SUPPORT STRUCTURE

To eliminate fretting wear caused by flow-induced vibration in recirculating steam generators, tubes are separated from each other by tube support lattice bars [1]. In the U-bend portion of the tube bundle, rows of tubes are separated by fan bars that radiate from collector bars located in the straight-leg portion of the steam generator [2].

The replacement steam generators constructed by Babcock & Wilcox International use Type 410S stainless steel with a specified maximum hardness of R 95 for tube support lattice bars, collector bars, and fan bars [3]. An autogenous weld is used to join the fan bar to the collector bar [4]. Corrosion tests were conducted to assess the stress corrosion cracking (SCC) susceptibility of welded type 410S stainless steel [5]. These tests included constant-extension-rate (CERT) tests and long-term immersion tests on 410S in various welded and heat-treated conditions [6].

The results of this test program demonstrate that, when highly stressed, the as-welded 410S weld joints are susceptible to SCC in steam generator environments [7]. However, highly stressed 410S autogenous welds given a post-weld heat treatment were not susceptible to SCC even under faulted steam generator operating conditions [8].

ABSTRACT # 48

ACCELERATED IGA/SCC TESTING OF ALLOY 600 IN CONTAMINATED PWR ENVIRONMENTS

An accelerated corrosion test (360 Degrees C for 2000 hrs) was performed on C-ring specimens machined from one heat of Alloy 600 tubing in the mill-annealed condition [1]. The specimens were exposed to secondary-side pressurized-water-reactor (PWR) solutions contaminated with lead, sulfur, silicon, and a combination of these contaminants [2]. Where possible, MULTEQ calculations were performed to determine the chemical concentrations so that a constant elevated-temperature pH of 4.5 was achieved [3]. This test was designed to examine the ability of these contaminants to cause intergranular attack and/or stress corrosion in stressed Alloy 600 tubing [4].

The results from this test demonstrated that under the test conditions used, lead-contaminated PWR secondary water induces and propogates intergranular attack (IGA) and stress corrosion cracking (SCC) in Alloy 600 [5]. Attack was intergranular; the degree of attack did not vary in the liquid or vapor portions of the test environments [6]. Although attack was more sever at higher stresses, significant attack was observed in samples stressed to the typical operating stress [7]. Solutions of only sulfur and only silicon displayed no initiation of propagation of either IGA or SCC [8]. However, the solution containing all three contaminants caused attack with identical morphology to that observed in the lead-contaminated solution [9].

VITA

Timothy J. Keogh received his BA in English in 1969 from Belmont Abbey College in North Carolina and MA in English in 1976 from Old Dominion University. From 1971 to 1973 he was a Linguist in Army Intelligence, receiving a degree in Modern Standard Arabic from the Defense Language Institute. After receiving his MA degree, he worked as a Writer/Editor for the National Institute of Education, the research and development branch of the Department of Education in Washington, D.C. In 1978 he moved to New Orleans to continue his graduate studies in English and Linguistics at Tulane. In 1979 he began working at the A.B. Freeman School of Business at Tulane as an Adjunct Professor of Management Communications where he presently teaches and directs the school's annual Language Orientation Program for international MBA students.

In 1980 he received a Fulbright Grant for graduate study in the humanities and spent one year at the University of Strasbourg in France. After returning to New Orleans, he continued graduate studies at Louisiana State University finishing his Ph.D. degree in the Fall of 1994. He served for four years on the National Council of Teachers of English Committee on Technical and Scientific Communication. For six years he was Manager of Corporate

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DOCTORAL EXAMINATION AND DISSERTATION REPORT

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